ARMY ORDNANCE

VOL. XXV, No. 141 NOVEMBER-DECEMBER, 1943

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The Caliber .50 Machine Gun
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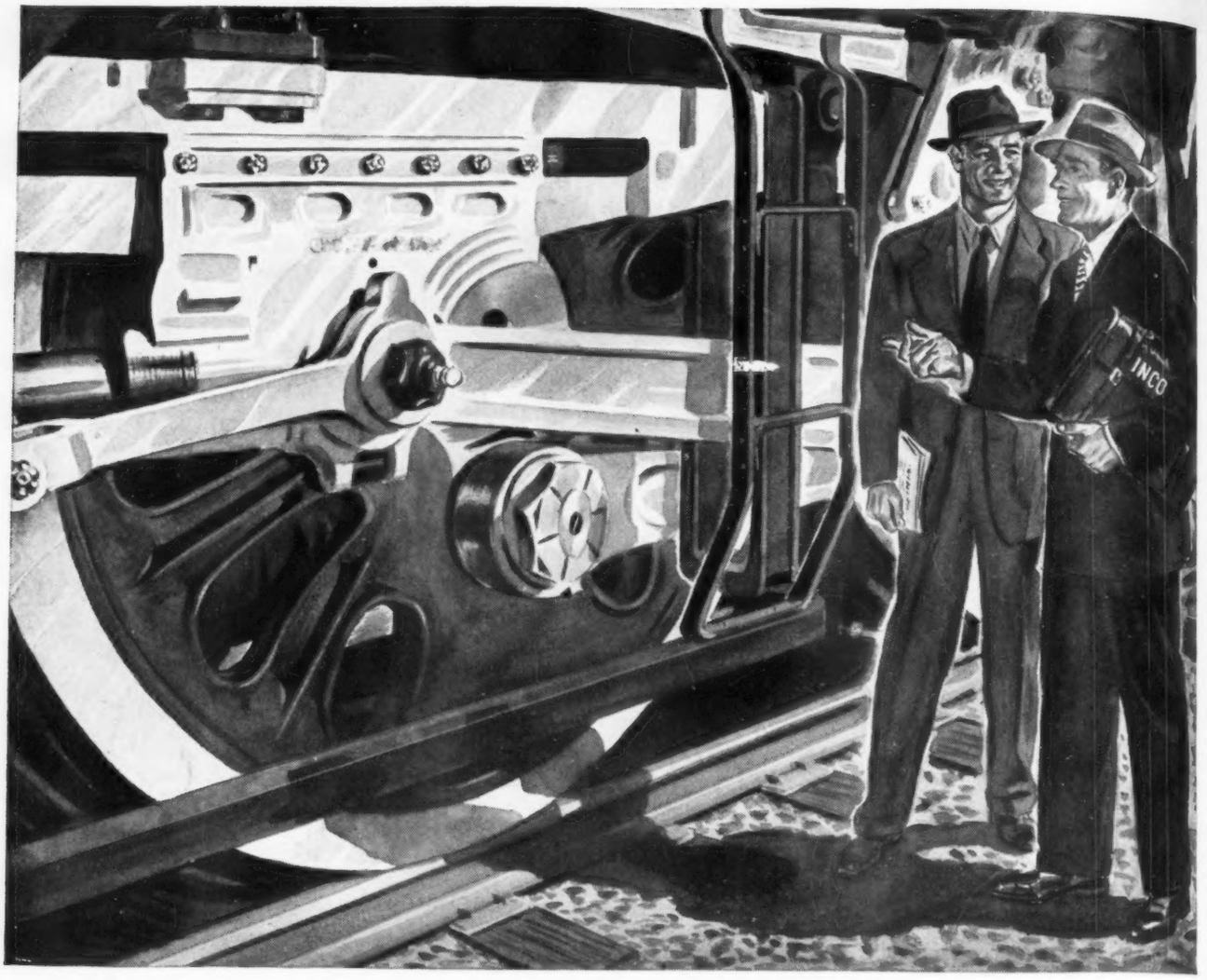
Col. E. S. Van Deusen

A REVIEW OF INDUSTRIAL PREPAREDNESS FOR NATIONAL DEFENSE
PUBLISHED BY THE ARMY ORDNANCE ASSOCIATION, WASHINGTON, D. C.



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ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Founded 1920

For Victory through Armament Research, Production, and Supply

Volume XXV | NOVEMBER-DECEMBER, 1943 | No. 141

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THE ARMY ORDNANCE ASSOCIATION

The Aims, Purposes, and National Officers of the Society

THE Army Ordnance Association, a national society of over 15,000 American citizens, was founded in 1919, "pledged to industrial preparedness for war as our nation's strongest guaranty of peace." The society was incorporated under the laws of the District of Columbia in 1928. Its entire energies are now dedicated to victory for the armed forces of the United States. For the duration of the war it is "pledged to victory—complete, absolute, final."

The Association has endeavored during the past twenty-four years to keep alive an interest in and knowledge of the design, production, and maintenance of military armament. This it has done through periods of public lassitude and times of great national emergency. Until 1940 there was no peace-time armament industry in the United States for the production of ordnance. Now all American industry is geared for victorious war production.

The principal objective of the society is an active membership of American citizens to assist in the design, development, procurement, production, maintenance, and supply functions of the Ordnance Department of the United States Army. When peace returns, this body of informed citizens will again continue to be a bulwark of knowledge, experience, and ability upon whom the Armed Forces of the United States can rely for technical and scientific assistance and for industrial preparedness.

The Association is devoted solely to the national defense; it has no commercial interests, no political alliances, and no religious affiliations. It is not operated for profit: its income is expended in furthering its aims. Its elected officers and directors serve without remuneration. Membership, to which American male citizens are eligible, is four dollars a year. (Application facing p. 592.) There are twenty-two local chapters of the Association throughout the United States.

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Guns against Aircraft

Organization and Function of the Army's Antiaircraft Command

Maj. Gen. Joseph A. Green

SHORTLY after the termination of the North African campaign, when conditions permitted the publication of military data, the American public began to learn, on the radio and in the press, of the effectiveness of American antiaircraft artillery in that theater. Such information, showing a total of over 500 Axis planes destroyed by British and American antiaircraft, evidenced the effectiveness of this component of our armed forces. While less glamorous and less publicized than some other components of the fighting team, the fact remains that antiaircraft artillery is today playing an extremely important part in every theater in which American troops are engaged.

The airplane on the ground is one of the most vulnerable targets to air attack. If surprised before a sufficient number of fighters can be sent aloft, an airfield provides a target composed of helpless planes, easily damaged or destroyed, with the gas tanks in every grounded plane an inflammable target for incendiary bullets. This fact was forcefully brought home to a horrified American public when it first learned of our terrific losses at Hickam Field in Hawaii and at Clark and Nichols Fields in the Philippines. Ground defense of airdromes must be provided in sufficient quantity unless we are willing to risk disaster. In addition, other ground installations in the theater of operations, and also elements of the field forces—armies, corps, and divisions—all require adequate antiaircraft protection or support. The problems posed by time and space are of such magnitude that friendly air support, unless greatly superior to the enemy, cannot possibly do the job alone. Because of the recognition of the need for positive protection from the ground against enemy air attack, our antiaircraft strength has been increased tremendously during the past eighteen months. This expansion is still continuing.

Antiaircraft artillerymen and antiaircraft artillery units are trained within the Antiaircraft Command of the Army Ground Forces. The Antiaircraft Command, with its headquarters at Richmond, Va., was activated upon the reorganization of the Army early in 1942. It comprises a sizable portion of Lieut. Gen. Lesley J. McNair's Army Ground Forces. Since the activation of the Antiaircraft Command, several hundred thousand antiaircraft troops have passed through its training centers or are now in process of being trained therein. This latter group includes more antiaircraftsmen than there were troops in our entire Army a few years ago.

Most of the facilities for training antiaircraft personnel and units have been developed during the current emergency. These facilities include eleven training centers located throughout the United States, two service schools, and two service boards. In addition to this, joint training facilities are operated with other arms and services. Of the eleven training centers, three are devoted to the training of loss replacements intended for shipment overseas—that is to say, individual soldiers trained to fill different positions set up in the tables of organization of antiaircraft units. At one training center—Camp Tyson, Tenn.—are located all barrage-balloon activities, including the training of units, the Barrage Balloon School, and the Barrage Balloon Board. At another training center—Camp Davis, N. C.—are located the Antiaircraft Artillery School and the Antiaircraft Artillery Board, in addition to one of the unit training centers. The six remaining centers are devoted to the training of complete antiaircraft artillery units and hence are referred to as unit training centers.

IN deciding upon the location of training centers, it was necessary to give first consideration to the possibilities for development of ranges that would permit the firing of guns of all calibers. At some centers—for instance, Camp Edwards on Cape Cod, Camp Davis near Wilmington, N. C., Camp Hulen near Corpus Christi, Tex., and Camp Callan north of San Diego, Calif.—firing is conducted over water, but in other locations it is carried on over land. Firing lines a mile or more in length accommodate many batteries simultaneously engaged in target practice. At each training center, hundreds of troops are to be seen on the firing line every day with other thousands receiving instruction elsewhere in the camp or nearby maneuver areas.

One of the many problems which have been met and solved since the United States entered the war has been the provision of a flexible antiaircraft organization suitable to modern warfare. The need for such an organization has long been realized but has become more apparent with reports of the varied demands made on antiaircraft as the war continues. After considerable study, the battalion has been evolved as the basic antiaircraft unit; it is administrative as well as tactical and can function as a separate unit when necessary. The four basic types of antiaircraft battalions, designated according to weapons with which armed, are gun battalions, automatic-weapons battalions, searchlight battalions, and barrage-balloon battalions. A further variation in designation is provided with respect to the transportation with which the battalions are equipped; that is, mobile, semimobile, self-propelled, and air-borne.

While the separate battalion constitutes the basic antiaircraft unit, the control of antiaircraft artillery during combat usually requires higher antiaircraft artillery echelons of command. To fill this need, group and brigade headquarters and

General Green is the Commanding General of the Antiaircraft Command, U. S. Army Ground Forces.

headquarters batteries have been provided—these organizations being purely tactical in their functions. These units—battalions, groups, and brigades—are capable of being associated together in various combinations to provide the proper balance of weapons needed for the job in hand, according to the dictates of the immediate tactical situation. Thus, in one case, a single automatic-weapons battalion may be assigned to a task alone, whereas in another situation a combination of heavy guns, automatic weapons, searchlights, and barrage balloons may be associated with fighter aviation and an aircraft warning net in order to provide a complete defense against enemy air attack. In another case, antiaircraft units, particularly those armed with automatic weapons, may be operating in close support of our mobile ground forces in providing them with added protection from enemy attack from the air as well as from the ground.

EVERY antiaircraft weapon is so designed that it is capable of firing upon ground as well as air targets. This is necessary because much of the antiaircraft matériel assigned to a field army is now placed well forward with the fighting forces in the divisional and corps areas. Frequently it is to be found in close juxtaposition to divisional artillery. In the North African campaign, tanks as well as troops quite often were targets. Training for fire upon ground targets receives major consideration in the training centers of this command and pays big dividends. As an example, an air-borne battery serving in the Southwest Pacific was flown into an airfield that had just been established in the New Guinea area. The enemy attacked the field with three rifle companies and, driving back our small force of defending infantry, was about to capture the field when he ran into the machine-gun fire of the antiaircraft battery. This proved to be the turning point in the fight, and the Japs were forced to retreat.

To be able to place shell bursts about enemy bombers that are miles away, to fire upon their close-in planes that are traveling at speeds of from 300 to 400 miles an hour, or to bring planes into a searchlight beam requires not only intricate mechanical and electrical equipment but also troops that are competent to maintain this equipment and to use it intelligently. Antiaircraft troops must be highly trained. In the training centers and schools of this command, antiaircraft troops learn how to use effectively the weapons with which their battalions are equipped. This training follows a prescribed pattern covering several months. The early part of it is devoted to developing the trainee into a soldier, teaching him what he needs to know for individual proficiency, and conditioning him physically for combat duty. This in turn is followed by the training of the small combat team such as the gun crew, then the battery, with the final phases being devoted to the training of the battalion as a whole. Great emphasis is laid upon realism, and to the maximum possible extent training activities are conducted under field conditions.

Upon the completion of the prescribed training in the training centers, the unit normally moves to a maneuver area for further training with ground troops or to other areas for combined training with appropriate elements of the Army Air Forces. Many of the battalions, groups, and brigades have received this postgraduate instruction in the Tennessee and Louisiana maneuver areas where divisions and corps are trained for battle under the watchful eyes of their commanding generals; others are to be found in selected areas on the east and west coasts of the United States where they are receiving combined training with the fighter commands of the First and Fourth Air Forces. The good account that antiaircraft units have given of themselves in the many theaters attest to the efficacy of this training cycle.

Supplementing the extensive training program referred to above is the Antiaircraft Artillery School, which is the point of origin of antiaircraft artillery doctrine, of enlisted technical specialists, and of officer personnel for the expanding antiaircraft component. The school conducts courses in which large numbers of technicians, such as automotive experts, electricians, fire-control specialists, and radio operators and repairmen are trained. It also instructs and trains specially selected enlisted men who, upon being graduated, are commissioned as second lieutenants and assigned to service with antiaircraft units. Thus far, more than 18,000 such officers have been commissioned. A third group includes some 1,500 student officers who have been returned to the school for specialized training or for advanced military instruction that prepares them to assume duties of greater responsibility.

The quality of the school training of both officers and enlisted men has been tested in combat, and large numbers of them have satisfactorily performed their missions under fire. Included in the instructor personnel at the school are battle-experienced officers. These officers bring to the school not only an accurate evaluation of the training required but also serve to give the students first-hand experiences which contribute greatly to the quality of the finished product. The Barrage Balloon School at Camp Tyson, Tenn., serves in a similar capacity in barrage-balloon matters.

AT the time the Nazi hordes ruthlessly attacked helpless Poland, our few antiaircraft regiments, both in the United States and its overseas possessions, were equipped with 3-inch antiaircraft guns and with caliber .30 and .50 machine guns on pedestal mounts that limited the guns to an elevation of only sixty-seven degrees. The necessities of war have brought forth startling changes. Today we have a highly perfected and battle-proved 90-mm. gun; the dependable 40-mm. gun with a cyclic rate of fire of 120 rounds a minute; the caliber .50 machine gun, with both single and multiple mounts that permit firing up to 90 degrees elevation; and an improved fire control.

For defense against low-flying hostile planes a large number of battalions have been equipped with quick-firing 40-mm. and caliber .50 machine guns. This type of battalion has been especially effective in the defense of our own front-line troops. It is of record that the Germans in the latter days of the North African campaign, in their desperate efforts to stop the allied advance, threw practically their entire air power against the front-line divisions. A staff officer who took part in the campaign reported to me that, over a period of weeks, 900 enemy planes attempted to attack from low altitudes the forward elements of the corps with which he was serving; that a very large number of them were shot down; and that the antiaircraft units carried out their mission so effectively that no great damage was suffered by the troops they were defending.

A few years ago, serious consideration was given to scrapping the caliber .50 machine gun. What a mistake that would have been, for this sturdy weapon has proved its worth on every battlefield and has exacted a heavy toll of targets engaged. Even the heavy gun and searchlight battalions are provided with some of these weapons for close-in defense. The self-propelled and the mobile and semimobile automatic-weapons battalions have them in large numbers.

Acme

AN ANTIAIRCRAFT CREW MANS A 40-MM. GUN AND ITS DIRECTOR IN TUNISIA

Searchlight battalions are equipped with lights of 800,000,000 candle power, the effectiveness of their beams being such that under normal atmospheric conditions they can readily illuminate targets at a distance of from eight to ten miles. Moreover, the mechanisms for controlling the movement of the beam have been so improved that it is difficult for an enemy bomber, once it has been illuminated, to escape from the light. He is blinded and is an easy prey for our own fighters or for antiaircraft guns on the ground.

IN addition to their mission of illuminating targets for gunfire, searchlight units are now extensively trained in joint operations with the Air Forces to illuminate targets for night fighters, to operate as orbit points for fighter activities, to indicate rendezvous points for bombers, and to guide returning friendly aircraft which have lost their way. As a testimonial of the effectiveness of the searchlight battalion, a corps commander serving in the Pacific recently reported that he had been privileged several times to see our searchlights locate Nipponese bombers which were shot down in flames by our night fighters—"to the acclaim of thousands and thousands of spectators in the darkened coconut groves." The fighter-searchlight team has proved to be a most effective answer to night attack by enemy aviation.

Every reader of this article knows that the advent of the airplane with its power to wreck cities, sink ships, and strafe troops on the ground has revolutionized methods of warfare. It has been axiomatic through hundreds of years that as soon as a new weapon of war is developed other weapons are designed to counter its effectiveness. This is the reason that ever since the first World War all the larger nations have bent every effort toward the design and manufacture of the very best antiaircraft guns and related equipment that it is possible to produce.

The problem of 3-dimensional fire control, necessitating the continuous and instantaneous flow of accurate future position data from computer to guns, naturally gave rise to the development of highly technical equipment. The responsibilities for the development of this intricate equipment devolved upon the competent personnel of the Ordnance Department. Maj. Gen. Levin H. Campbell, Jr., Chief of Ordnance, working in close coöperation with groups of American scientists and inventors such as those controlled through Dr. Vannevar Bush's Office of Scientific Research and Development, has produced antiaircraft guns and fire control that, to express it moderately, are at least the equal of those of any other nation.

Antiaircraft is now an established weapon on both offense and defense. It has definitely won its place. The Antiaircraft Command of the Army Ground Forces, with full realization of the importance of its mission, will continue to supply personnel with the high order of training required; to keep abreast of changing conditions and doctrines under which antiaircraft artillery troops are employed; and, by constant evaluation of combat experience and intelligence, will continue to coöperate with the Ordnance Department in keeping our matériel developments well in advance of anything our enemies may produce.

EDITOR'S NOTE.—Among the principal antiaircraft weapons used today by the U. S. Army are the caliber .50 machine gun which fires tracer, incendiary, and armor-piercing bullets against low-flying aircraft; the 37-mm. antiaircraft gun firing explosive projectiles against low- and medium-flying airplanes; the 40-mm. gun on 4-wheel mount which may be used against air or ground targets and has an approximate range of 7,500 feet—8 guns constitute the normal battery and each gun has its own director and generator; the 3-inch gun which was our standard antiaircraft weapon for some years; the 90-mm. gun which is now our principal heavy weapon for use against planes—it is mounted on a single-axle, dual-wheel, highly mobile carriage.

The Battle of Production

Ordnance Meets the Challenge of a $60,000,000,000 Program

Brig. Gen. Hermon F. Safford

SINCE the United States declared war on the Axis, American industry has surpassed all records in production of war materials. As a direct result, our Army, Navy, and Marine Corps have turned the Japanese tide in the South Pacific, the British and Americans have chased Rommel out of Tunisia and invaded Sicily and Italy, while Russia continues to turn the German invasion into a retreat.

America's great and rapid production made all this possible. As Americans, we can be justly proud of this record of production—a record never before equaled in all history; a miracle of production surpassing, in *two* short years, the mass production of the Axis over a *10-year* period. The prized propagandist of the Axis, Dr. Goebbels, made the remark some time ago that Germany had taken seven years to amass a tremendous amount of war material which could never be equaled. How could it be expected that England or America could ever catch up with Germany? Yet, in one year, the United States not only has equaled German production of war materials but has outstripped the combined efforts of the Axis powers.

This mass production of ordnance presents an almost unbelievable picture. A billion-dollar corporation requires expert management and untiring effort on the part of top-notch executives and engineers, and it takes years of training to produce such executives and engineers. Let us take a look at the growth of some of our largest business enterprises. A few large corporations which can be taken as typical examples of American industry present an excellent comparison: The United States Steel Corporation increased in annual volume of business in the 41 years since 1902 approximately 200 per cent; the General Motors Corporation has increased its rate of output by about 800 per cent over the period 1918 to 1942; the rate of output of the General Electric Company has increased about 3,000 per cent in 44 years since 1899.

THE Ordnance Department, by comparison, has been faced with an expansion program far more rapid than anything ever before known. From a rate of production of about $1,000,000 a month in May 1940, the output has expanded to over $1,500,000,000 a month—an increase of about 150,000 per cent in 3 short years. These figures will give some idea of the problems of organization, personnel, and management that had to be solved to make possible such an expansion in this brief period.

What picture does this present when translated into terms of dollars? For years the Ordnance Department operated under a total annual appropriation of seven to ten million dollars. The production program for World War I in Ordnance matériel alone amounted to slightly over four billion dollars. Today, orders total *over sixty billion dollars!*

What does this mean when translated into quantities of war material? Our Commander in Chief, the President of the United States, in his address on the State of the Nation before the opening of the Seventy-eighth Congress, gave the following outstanding examples:

> In 1942 we produced 56,000 combat vehicles, such as tanks and self-propelled artillery. We produced 670,000 machine guns—6 times greater than our production in 1941 and 3 times greater than our total production during the year and a half of our participation in the first World War. We produced 21,000 antitank guns—6 times greater than our 1941 production. We produced 10,250,000,000 rounds of small-arms ammunition—5 times greater than our 1941 production and 3 times greater than our total production in the first World War. We produced 181,000,000 rounds of artillery ammunition—12 times greater than our 1941 production and 10 times greater than our total production in the first World War.

A check of the record of production of cannon of all types at Watervliet Arsenal showed to our amazement that more cannon had been produced during the present war than during the entire 130-year history of the arsenal. Similar accomplishments could be cited for other arsenals.

The Ordnance engineering knowledge and experience gained at our arsenals under very adverse conditions since the last war have been freely given and freely used to assist American industry in converting its efforts from peacetime to wartime production. This, coupled with American industry's well-known capabilities for mass production, makes an unbeatable combination. *Our combat troops have not suffered in battle because of the lack of ordnance.*

THE quality of war material, as well as excellence of design, is responsible for the soldier's faith in the dependability of his weapons. This requires an efficient and thorough system of inspection. At the start of this war, the Ordnance Department had approximately 200 experienced inspectors. From this nucleus, it was necessary to build up an inspection organization to take care of some 10,000 prime contracts and 70,000 subcontracts. Training schools were set up in our arsenals and universities in order to prepare new inspectors for their duties as well as time would permit. The total civilian inspection force now operating on Ordnance contracts is slightly over 21,000—an increase of 10,000 per cent.

As might be expected in work of this nature, we had—and still have—our troubles; but as time goes on, this force gains in experience, and the complaints received due to the improper exercise of judgment by inexperienced inspectors are being reduced materially. Complaints now are seldom due to acceptance of inferior material but generally to an exaggerated demand for perfection.

It is fundamental in the organization of the Ordnance Department that the final inspection of any ordnance material be performed by an inspection unit completely independent of the unit responsible for the production of the

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material. In Ordnance arsenals, the final inspection is performed by inspectors who are responsible to the commanding officer alone. The commanding officer is responsible for the quality of the items produced. The same principle holds true in the acceptance of material produced by industry. In this case, final inspection is performed by inspectors responsible only to the chief of the Ordnance district in which the item is fabricated.

For each item of ordnance, complete sets of inspection-gage drawings are provided. The Ordnance gaging system insures complete interchangeability of parts and is recognized throughout the country as an engineering masterpiece.

In addition, the Ordnance Department operates proving grounds for sample testing. Ammunition samples from each lot are subjected to firing tests prior to final acceptance. Cannon are sent to the proving grounds for firing tests, as well as selected combat vehicles. These proving-ground tests serve as an independent check on the effectiveness of plant inspection.

HERE are some of the comments from the battlefield, showing the results of the operation of this system:

North Africa.—Reports from the fighting front in North Africa praised the performance of the new 105-mm. howitzer motor carriage, M7, on the battle front. This vehicle has proved itself to be an unusually rugged and trustworthy tank destroyer as well as excellent mobile field artillery. It carries its own antiaircraft protection from low-flying planes and makes an excellent companion vehicle for tank forces. An Armored Force commander says:

"The natural enemy of the tank is not another tank, but the gun. This gun must be able to outrange and outsmash the tank's armament. It must be carried by a self-propelling platform. The vehicle must surpass the tank in speed and mobility, and will therefore be armored lightly. While the tank wars on ground personnel in general, the tank destroyer specializes in fighting only tanks. Ambuscade, based on sound reconnaissance, is the destroyer's particular forte."

Algiers.—A cablegram from Algiers describes how nine enemy aircraft were destroyed by one multiple-gun motor carriage. One aircraft was shot down with a burst of two hundred caliber .50 and five 37-mm. rounds of ammunition while the gun motor carriage was still on a lighter, one while the weapon was still on a sea train. The message indicates that this weapon is very effective against low-level air attack.

Southwest Pacific.—A report from the Southwest Pacific theater on performance of small-caliber automatic antiaircraft weapons (40-mm., 20-mm., calibers .50 and .30) states:

"Two occasions were observed when automatic weapons went into action. In one instance, 3 Japanese bombers flew over the defended area at an altitude of about 5,000 feet. One aircraft was destroyed by fire from automatic weapons. On the other occasion, 18 Japanese aircraft flew over the defended area at an altitude of about 5,500 feet, which is extreme range for these small-caliber weapons. Three planes were destroyed."

Middle East.—Maj. Gen. C. L. Scott, Commanding General of the Armored Force Replacement Training Center, Fort Knox, Ky., has praised the performance of American matériel in the Middle East where he was stationed as a senior military observer for the United States from March to July 1942. Writing in ARMY ORDNANCE for January-February 1943 (Vol. XXIV, No. 136, p. 67), General Scott reported:

"As to equipment, our rifles, machine guns, artillery, trucks, peeps, jeeps, scout cars, armored cars, light and medium tanks, combat planes—all are giving splendid service there in the desert. After witnessing these active operations, in my opinion and in the opinion of the great majority of British personnel using it in battle, this American equipment, item for item, is at least equal, and in many cases superior to both German and Italian equipment. The performance of our tanks was especially gratifying. . .

"The fact that the German 88-mm. gun did knock out many tanks caused unjustified criticism of both the British and American vehicles. . . The German 88-mm. gun is simply a large-caliber, high-velocity, combination antiaircraft-antitank gun which will knock out, at ranges up to 3,000 yards, any light or medium tank which we, the British, the Germans, or the Japanese can produce. It is the same old story of gun superiority over armor. . . It is revealing no military secret to tell you that we have and are producing weapons which will not only match, but which will outmatch, Rommel's prize gun."

These questions resolve themselves into one of superior firepower, and the United States has this superiority. We have three American weapons which can outmaneuver, outshoot, and destroy the 62-ton Mark VI German tank. One is the M7 self-propelled 105-mm. howitzer already mentioned. It is larger than the 88-mm., has a much heavier shell with a much greater bursting charge, and has a longer effective range against tanks. Another weapon is the M10 tank destroyer with a 3-inch high-velocity gun mounted in an open turret, one shell from which could destroy the Nazi Mark VI at long range. Another is the 90-mm. gun.

VICTORY will be won by firepower, or a combination of TNT and steel. A heavy tank such as the Germans are using was rejected by our Army for two very sufficient reasons. First, it does not pack enough firepower to warrant all the weight and mechanism, and, secondly, it is too slow and therefore lacks maneuverability. The decision *not* to use large quantities of heavy tanks appears justified in view of the fact that our artillery firepower is more than a match for the heaviest enemy tanks.

Another new antitank weapon is the shoulder arm known as the "Bazooka." This is a short-range, low-velocity weapon used by the individual soldier from fox holes during tank attacks. This weapon came by its name honestly, since it is made from a light steel tube similar to that which Bob Burns converted to his famous "Bazooka." A missile from this weapon will penetrate any tank. (See illustrations on p. 566.)

And what about the ammunition for these weapons? It must pass the most rigid inspection of dimensions and metallurgical perfection. Only ammunition which has successfully passed *all* tests is issued to combat troops, and only *specially selected* ammunition is used in aircraft machine guns where failure for any cause may mean the loss of both plane and pilot.

Our armor-piercing, tracer, and incendiary bullets in the caliber .50 aircraft machine guns literally tear enemy ships apart in the air. They are responsible for the feats of such aces as Captain Foss of the Marine Corps and his Army Air Corps brothers flying at Guadalcanal and Tunisia. We can have the best trained armies in the world, but without proper equipment these armies would be helpless. Our combat troops have supreme confidence in their equipment.

It will be immediately apparent that the planning and scheduling of ordnance production is a job of the first magnitude. It is essential that the flow of materials be maintained to meet required deliveries and that forecasting of actual production must be accurate. This is necessary in order that tactical and strategic plans can be based on firm knowledge of the equipment which will be available for any planned military operation. The problem is essentially the same as that encountered in any mass-production industry, and it has been approached thus by the Ordnance Department.

Production planning has been studied by the Ordnance Department for years to the end that when an emergency arose, the methods for assuring balanced production of ordnance items would already be established. The planning methods developed have proved sound in operation. However, to further refine the methods employed, the Ordnance Department has obtained from industry the services, as consultants, of men who have spent their lives in industrial production planning. These men have given freely of their time and experience to assist us in this great problem.

THE methods used follow industrial practice closely. The master schedule of all major items of ordnance is set up on a basis of balanced production to meet the Army's requirements. Basic unit weight bills of material have been, or will be, supplied by all contractors. The determination of the over-all requirements for critical materials is a matter of mathematical processing of the bills of material and the master schedule.

These material requirements, which are definitely tied to the major-item schedules, are submitted, together with other War Department requirements, to the War Production Board in accordance with the regulations of the Controlled Materials Plan. The control of the Nation's resources of critical materials is an extremely difficult task, and there is no perfect means for its accomplishment. The job must be done, however, no matter how difficult.

The scheduling procedure which has been followed by the Ordnance Department throughout the present production program has shown excellent results. For the calendar year 1942, deliveries of Ordnance items were within fifteen per cent of the over-all forecast. It should be apparent that for a $60,000,000,000 program this is a good job of scheduling.

It must be remembered that in this war the United States is not supplying the U. S. Army alone. It is supplying the land, sea, and air forces of the United Nations, as well as a considerable portion of their civilian requirements. Our materials must go to Russia to provide the essentials without which their present successful campaign would be impossible. They must go to China, to Sicily, to England, to Australia, and to the farthermost corners of the world. This has placed a demand upon our resources never before dreamed of. It has brought about the necessity for the most careful measures of conservation and substitution to permit the greatest use of the available critical materials.

The Ordnance Department long ago instituted procedures to this end. It was done through the establishment of industry integration committees whereby manufacturers of the same ordnance items can pool their resources in order to conserve material, equipment, and man power. It has been done through a suggestion and conversion system whereby contractors for ordnance material are encouraged to submit suggestions for the improvement of ordnance specifications and drawings. These suggestions are handled through a special section in the Ordnance Office made up of industrial engineers trained in the most modern production methods. Over 3,300 of these suggestions have been received, and over 1,200 have been accepted and put to use. Here are a few striking examples of the results obtained:

1. An adapter booster, used in artillery ammunition, weighing only a few ounces, was formerly manufactured from bar stock on automatic screw machines. The material was changed to pressed steel with the resultant saving on a single order of 210,000 man-hours and enough steel to produce 1,500 of the famous 4,000-pound blockbuster bombs.

2. Primer tubes, also weighing just a few ounces each, were changed from brass tubing to steel stamping, saving 30,000 tons of brass—enough to provide all the brass requirements for 184 destroyers.

3. Approximately 2,000,000 fin lock nuts were changed from forgings to stampings, saving 100,000 machine-hours, $283,000, and enough steel for the manufacture of 11,500 Garand rifles.

4. A cartridge tank change-over from aluminum to steel saved enough aluminum to produce 550 bombers.

5. The new submachine gun, caliber .45, M3, is made almost entirely from stampings at a cost of approximately $19 each—a saving of about $20 over other types of submachine guns.

Trifles? Yes—but *tremendous* trifles, and these are but few of many. Such savings have been effected in steel alloys, copper, brass, aluminum, rubber, and even in the 28-inch width semi-high-tenacity rayon now substituted for the 36-inch width high-tenacity fabric formerly used for the parachutes attached to low-altitude fragmentation bombs—a change which saved 12,000,000 pounds or enough to make 920,000 parachutes.

THE Ordnance Department produces approximately 1,700 major items of equipment, such as tanks, trucks, cannon, machine guns, and ammunition of all kinds, not to mention many hundreds of minor items. The determination of the quantities and the desired military characteristics of these items is a General Staff function. Engineering, design, procurement, production, inspection, supply, and maintenance are Ordnance functions.

Based upon battle experience, the Staff might say: "We need more ships and planes and less ordnance." Or, speaking of ordnance equipment, they might say: "We need more medium tanks and fewer light tanks. We need more armor-piercing bullets for aircraft and antiaircraft machine guns. We need a greater proportion of 4,000-pound bombs for demolition work."

Can the Ordnance Department say: "No, you can't have 4,000-pound bombs because we are tooled to produce 2,000-pound bombs"? Can we leave our pilots without armor-piercing bullets because we are tooled for ball and tracer bullets in larger proportions? Can we say to our Armored Force, "You must use more light tanks," if battle experience has taught them that they need a preponderance of medium tanks?

The Army, the Navy, and the Air Forces cannot predict their requirements with certainty months in advance but must be ready to meet the constantly expanding or changing situations occasioned by the shifting tides of war. It is therefore apparent that our production plans *cannot* remain fixed. We must be prepared to produce new items on short notice in order to maintain superiority of armament in the field.

Trucks That Go Down to the Sea

Evolution of the Army's Vehicles for Amphibious Operations

Col. E. S. Van Deusen

THE first definitely expressed requirement for amphibious vehicles in the United States Army was formally presented when the military characteristics for the ¼-ton, 4x4 truck, were drawn up on June 27, 1940. These military characteristics specified that the vehicle was to be amphibious, if practicable. However, these amphibious requirements were not incorporated into the specifications for the ¼-ton, 4x4 truck, as it was not considered possible of accomplishment at the time without a complete redesign of body and chassis.

This does not mean, however, that amphibious motor vehicles had received no attention by the Army prior to 1940. Rather, the recorded action of the board which formulated the military characteristics of the ¼-ton truck represented the crystallization and official recognition of the theory, formerly considered "crackpot," that amphibious vehicles were practicable and desirable for military use. War Department files prior to 1940 contain quite a volume of correspondence relating to amphibious-vehicle designs and proposed methods of "amphibianizing" conventional equipment. These files include references to experimental work pursued by officers and enlisted men as well as commercial organizations and private individuals and show consistent application of effort to the problems over the entire period subsequent to 1920.

The majority of these efforts appear to have been devoted to the development of auxiliary flotation equipment which could be attached to conventional cars and trucks when the need arose and hence they cannot be classified as truly amphibian projects. This approach was investigated quite thoroughly during the early stages of the program initiated early in 1941, but the results were so far from satisfactory that it was abandoned. Fig. 1 shows one device which floated the ¼-ton truck, but it was sadly lacking in the other characteristics demanded for military use and added little to the improvised method of ferrying developed by the Corps of Engineers through the use of tarpaulins. An outboard motor provided the power for propulsion through the water.

It was known, from commercial literature and military reports in the late 'thirties, that the European armies were toying with the amphibian idea, one experimental design being based on the use of commercial engine and axle components. No such vehicles have been introduced by the enemy in action or service to date, however, so it is to be assumed that our progress with amphibious truck development and the production of practical designs have far outstripped that of the Axis powers.

The War Department was first approached from the commercial field with a proposition to buy and test an amphibious vehicle according to designs submitted by the Aërosled Company in January 1940. The design submitted was not practical, and further research by the company resulted in the offering of a more practical design in July 1940. This proposal was turned over to the National Inventors Council for investigation. The N.I.C., after study, referred the matter back to the Ordnance Department as an entirely practical design. However, at that time there was insufficient information regarding requirements for that type of equipment in the Army to warrant setting up a development program and expending the limited funds available at the time for such a project. However, Mr. Roger Hofheins of the Aërosled Company went ahead on his own initiative, organized the Amphibian Car Corporation, and commenced construction of a pilot-model vehicle in February 1941.

IN the early part of March 1941, the Quartermaster Motor Transport Subcommittee of the Quartermaster Technical Committee, following through on its previous action with the Motor Committee Minute of the ¼-ton truck, made the recommendation that an investigation be initiated to develop a light amphibious vehicle comparable in size to the ¼-ton, 4x4 truck, since amphibious qualities had not been obtained in that vehicle. The recommendation was approved by The Adjutant General's office, and this approval also provided the basic policy for the later development of larger amphibious vehicles. On April 17, 1941, the National Defense Research Committee was requested to carry out the necessary research on an amphibious vehicle to carry a payload of approximately a quarter of a ton, and the building of four pilot models was authorized. The N.D.R.C. contracted for the services of Sparkman & Stephens, Inc., of New York City, a yacht-designing firm, to conduct the research on the design of the vehicle, especially the hull. Mr. P. C. Putnam was assigned to the project by the N.D.R.C. and Mr. Roderic Stephens, Jr., undertook the supervision of the engineering for Sparkman & Stephens. The Holabird Quartermaster Motor Base also was directed to study the problem of converting the ¼-ton, 4x4 truck into an amphibian.

In the meantime, Mr. Hofheins had been building his first vehicle, and it was completed and successfully tested on May 19, 1941. A demonstration of this model, named the "Aquacheetah," was held in Buffalo, N. Y., on May 27, 1941, by the Amphibian Car Corporation for the benefit of interested representatives of the War Department. The vehicle demonstrated was an all-wheel-drive design with a hull resembling a broad-beamed barge in contour. The basic axles used were standard Dodge type, as used in the ½-ton, 4x4 truck, but all wheels were independently sprung and driven by enclosed chains from the stub axles. The vehicle was powered with a commercial Ford V-8, 85-horsepower engine which was mounted amidship, and attained in the demonstration a water speed of approximately six miles an hour. The drive in the water was secured by a retractable propeller in a stern tunnel, and steering was accomplished by a rudder. Seating capacity was provided for six persons. The maneuverability of the vehicle was demonstrated by driving it in and out of the Niagara River. Following the demonstration, the pilot "Aquacheetah" was delivered to the Holabird Quartermaster Motor Base for further tests, after which the Quartermaster Corps was authorized to procure eleven additional

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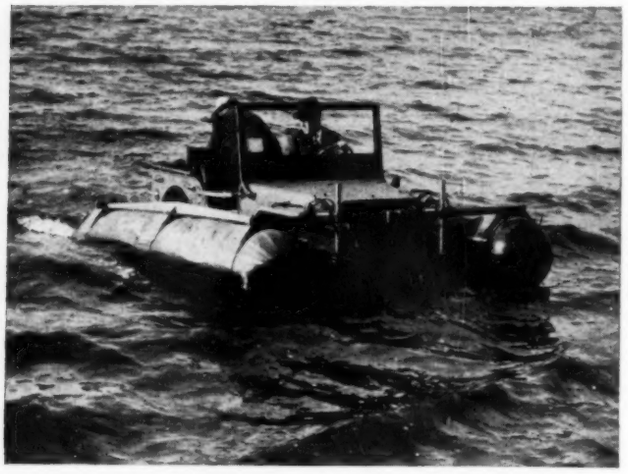


FIG. 1. "AMPHIBIANIZED" ¼-TON TRUCK, 1941

similar vehicles. Fig. 2 shows the pilot model of these trucks, as demonstrated at Buffalo.

Characteristics were prepared covering the military features of construction and the performance requirements for a ½-ton, 4x4 amphibious truck. These characteristics required a 1,000-pound payload, with a gross weight of approximately 5,400 pounds. The vehicle was required to attain a land speed of fifty-five miles an hour, and the minimum acceptable water speed was five m.p.h. Tire equipment was specified to be 7.50-16 size, mud-and-snow tread, standard on the ½-ton, 4x4 trucks. The electrical system was to be either six or twelve volts, but only the latter was produced. The pilot-model trucks were scheduled for service tests by the Armored Force, Cavalry, Corps of Engineers, Infantry, Ordnance, Signal Corps, Quartermaster Corps, and Medical Corps, and one was furnished to the British Army.

FIG. 2. THE FIRST PILOT ½-TON "AQUACHEETAH," MAY 1941

Deliveries of these service-test trucks were secured during the early part of 1942, and preliminary reports indicated their performance as being satisfactory with correction of minor construction details. At about this time, however, the ¾-ton, 4x4 truck was standardized in place of the ½-ton design, and orders were issued for conversion of the "Aquacheetahs" to include the new components involved, consisting, principally, of slightly larger engines, heavier axle construction, and the use of 9.00-16 tires. At the time the manufacturer accomplished these modifications, one additional truck was procured, and all vehicles were again submitted to the service boards. Fig. 3 shows the latest design of this amphibious truck, which can be produced on a volume basis if required.

The "Aquacheetahs" were quite successful, within their limitations of size and cargo capacity, and it was proposed that further refinements be accomplished with a view to adoption as a standard vehicle. However, due to the concurrent development of the ¼-ton amphibian, the speed with which that project was completed, and the subsequent development of the larger 2½-ton amphibian, the War Department decided to drop the "Aquacheetah" project because there appeared to be no requirement for amphibious vehicles of the intermediate size represented by the ¾-ton design.

ON February 18, 1942, the Quartermaster Motor Transport Subcommittee met in Dearborn, Mich., to witness a demonstration of the first pilot model of the ¼-ton, 4x4 amphibious truck, as developed by the National Defense Research Committee and built by the Ford Motor Company. This vehicle was based on the use of standard components of the ¼-ton, 4x4 truck, such as the engine, axles, steering gear, etc. Its amphibious characteristics were demonstrated by operation in and out of the Huron River near Ypsilanti, Mich.

Of the four pilot models which had been authorized under the N.D.R.C. project, one was built by the Marmon-Herrington Company, of Indianapolis, Ind., concurrently with the first one built by the Ford Motor Company. These two were quite similar in general appearance and arrangement, differing only in constructional details. Fig. 4 shows the Ford-built pilot during the original demonstration, with Mr. Stephens at the wheel. The two other pilot trucks were built by the Ford Motor Company, Messrs. Clarence F. Kramer and Floyd G. Kerby of that organization being assigned the responsibility of supervising the engineering involved in possible quantity production. The last one built incorporated many improvements and changes indicated by the preliminary testing and examination of the first pilots, notably the rearrangement of the seating and cargo space to make it as nearly identical with that of the land vehicle as practicable.

On April 11, 1942, prior to the completion of the projected service-board tests of the N.D.R.C. pilot models, a directive from the War Department General Staff was received by the Quartermaster General for the procurement of several thousand ¼-ton, 4x4, amphibious trucks, as soon as possible. In view of the

FIG. 3. THE ¾-TON "AQUACHEETAH," FALL 1942

advanced stage of engineering and the existing production of ¼-ton trucks in its facilities, the Ford Motor Company was directed to undertake the manufacture at once. As a result of this rush requirement, tooling for production was commenced by the Ford Motor Company in accordance with the verbal instructions and prior to receipt of a formal contract. The final pilot-model vehicle was immediately returned to the factory for tooling checks, and production plans were developed which resulted in eliminating about six weeks in the normal procurement routine and getting into production that much sooner.

The ¼-ton amphibian differed from the "Aquacheetah" in basic design in that the latter, while incorporating the major components of a standard truck, was laid out in a non-conventional arrangement, with the engine in the rear, while the ¼-ton design retained the normal placement and relationship between components, almost identical with that of the land vehicle. In fact, in so far as principles are involved, the ¼-ton amphibian is a Jeep with the wheelbase lengthened by about four inches and with a watertight hull, molded to fit, added in such a manner as to permit the axles, which are conventional in all respects, to oscillate outside the hull. The marine propulsion is similar to that of the "Aquacheetah" except that the propeller is not retractable and is positioned in the tunnel at a point high enough to assure full ground clearance and angle of departure. Fig. 5 shows the ¼-ton design as produced in quantity during 1942 and 1943. To this vehicle was accorded the honor of transferring General Eisenhower from ship to shore in the invasion of Sicily.

FIG. 5. THE ¼-TON AMPHIBIOUS JEEP OF TODAY

THE original conception of the amphibious ¼-ton truck was based on its probable usefulness as a scouting, reconnaissance, and raiding vehicle over terrain which might require traversing rivers and lakes. It was equipped with a 12-volt electrical system to permit the installation and operation of high-powered 2-way radio equipment. Primarily a personnel carrier, it was not intended as a substitute for the parallel land vehicle, and the added weight of the hull and additional marine operating equipment naturally created a definite handicap to its land performance, although it has surprising ability, not so far below the normal truck on land. Its usefulness in flood rescue work during 1943 has been the subject of feature press articles, and, properly assigned and used in military operations, it should find a definite place in equipment tables.

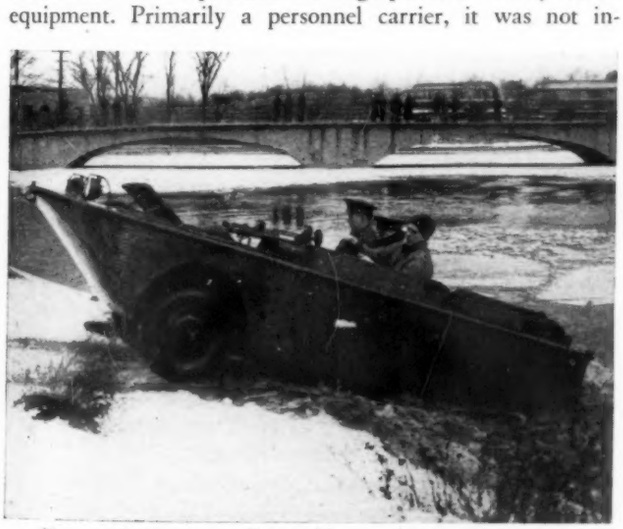


FIG. 4. FORD-BUILT PILOT ¼-TON AMPHIBIAN, 1942

FIG. 6. THE "DUCK"—2½-TON AMPHIBIOUS TRUCK

On April 15, 1942, immediately following the directive to procure the ¼-ton amphibian in quantity, the Quartermaster Corps was authorized by the War Department to pursue the development of an amphibious truck based on use of the standard 2½-ton, 6x6 truck and its components. The research on this vehicle was also turned over by the Quartermaster Corps to the N.D.R.C., and the firm of Sparkman & Stephens was again designated by the N.D.R.C. to conduct the detail work involved, in view of their success in the ¼-ton project. A development contract between the Yellow Truck & Coach Division of General Motors Corporation and the N.D.R.C. was signed on April 30, 1942. On June 12, 1942, forty-three days after the development contract was signed, the first pilot model was demonstrated to the Quartermaster Motor Transport Subcommittee at the proving ground at Milford, Mich.

The vehicle had a rated pay-load capacity of 5,000 pounds, a gross weight of 18,000 pounds, and was constructed of the chassis components of the 2½-ton, 6x6 truck, with 164-inch wheelbase. The basic principles of "amphibianizing" were almost identical with those applied to the ¼-ton design. The engine was the GMC 270-cubic-inch, the same as used in the standard cargo truck. This original pilot truck was mounted on the standard land vehicle's 7.50-20 tires, with dual wheels on the rear axles. Tests over sand beaches later indicated the use of tires of larger cross-section, with single wheels on the rear to secure the advantageous maximum flotation resulting from this combination.

Following the demonstration at Milford, the vehicle was driven overland to Fort Belvoir, Va., where it was shown to other interested members of the Army Ground Forces and the Army Service Forces. On June 23, 1942, the vehicle was taken to Fort Story, Va., for testing in the ocean surf. The Quartermaster Motor Transport Subcommittee was present at these tests on that date, but due to a light surf condition, no conclusive tests could be conducted. The vehicle was to remain at Fort Story until a satisfactory surf was available, but on June 24, 1942, the Commanding General of the Army Service Forces, satisfied from the preliminary tests that the vehicle would be extremely valuable to the Army, directed the procurement of several hundred units, and the pilot-model truck was returned to the manufacturer to aid in tooling for production.

AS in the previous project, many minor and some major changes were introduced into the design of the "Duck" during the early stages of production. The name "Duck," by the way, originated by coincidence and accident from the model designation applied by the manufacturer in following the normal commercial method of using key letters and numerals to indicate the model year, type of drive, and equipment. This code resulted in the combination "DUKW" as supplying the proper key, which naturally became "Duck" on the tongues of American soldiers when they were first introduced to this rather startling vehicle, which gives the appearance of serenely floating on quiet water and waddling on land much like the fowl its name suggests. Fig. 6 shows the final model of which thousands have been built.

A substantial number of "Ducks" were produced and delivered to the Army in 1942, and comprehensive tests showed them to have remarkable ability over the toughest sort of beaches and through surf too heavy for successful negotiation with the ordinary shore-launched boats used by the Coast Guard. Experimentation by the Engineer Amphibian Command and the Transportation Corps proved their value in landing operations, both for assault purposes and for the movement of supplies from ship to shore in the absence of adequate dock facilities. These trucks have rendered valuable service in recent amphibious operations and in at least one instance have been recognized in enemy dispatches as being worthy of special note, "near hits" on "an amphibious truck" being listed in a Japanese report of damage recently claimed to have been inflicted on an allied Southwest Pacific task force along with hits claimed on a number of fighting ships and transports.

The "Duck" has an over-all length of approximately 31 feet, a width, or beam, of approximately 8 feet, and is about 7 feet high when its canvas top is down. The vehicle has a dry shipping weight of 14,100 pounds. On land, the "Duck" can carry approximately thirty-five men; on water, it can transport fifty men, or more, depending on the freeboard required to negotiate a particular water crossing. While on land, the vehicle drives through all six wheels; in the water it is driven by a rear-mounted propeller. The axle and water propeller shafts pierce the hull through sealed tubes or openings. The steering gear is connected to the rudder so that normal operation of the steering wheel guides the vehicle in the water. The propeller drive can be augmented, when necessary, by the revolution of the driving wheels. Thus, prior to entering or leaving the water, the driver can shift controls to provide a land-and-water drive to avoid getting stuck. A winch is mounted on the rear deck of the vehicle in such a manner that the cable can be used effectively from either end. Essentially, the amphibian is not a combat vehicle; however, it will doubtless prove of value in forcing river crossings and in surprise landings where shoals, reefs, or sandbars are encountered which ordinarily would render the use of an assault boat impractical.

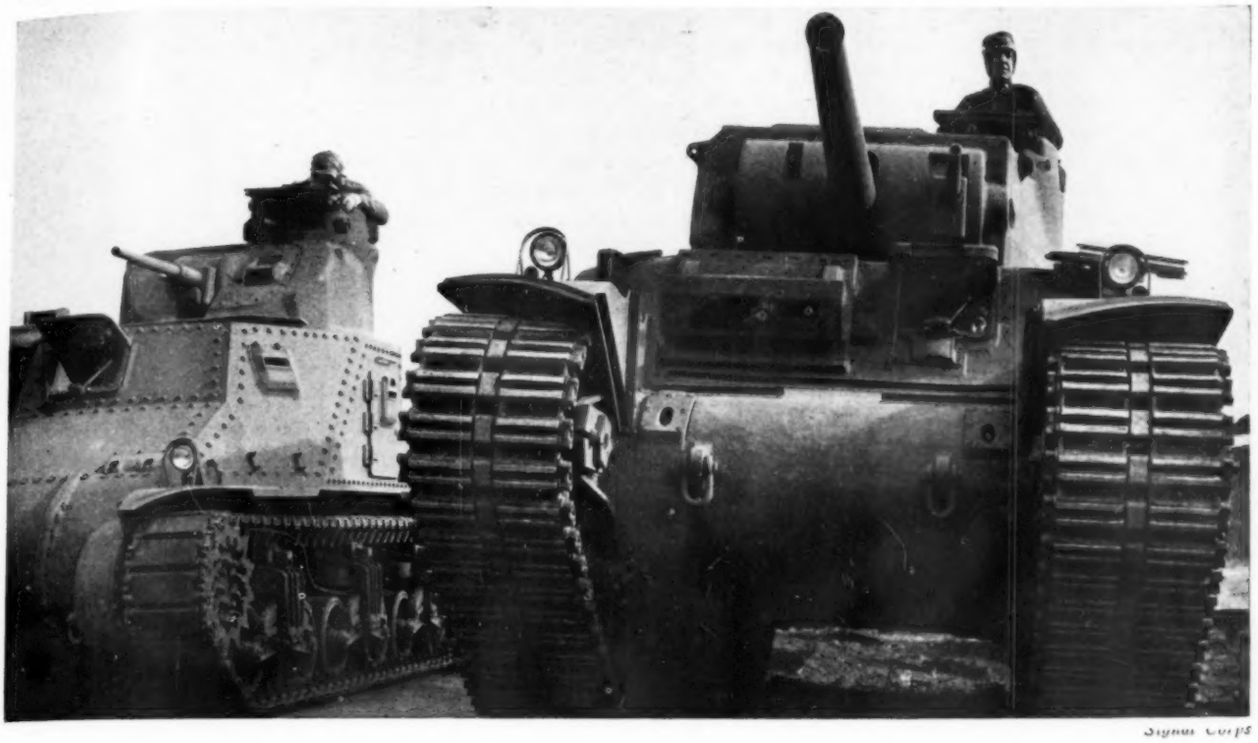
The only amphibious truck, other than those described above, which the writer is at liberty to discuss at this time is one which was tested briefly during the early part of 1942 concurrently with the original pilot models of the ¼-ton design. This was known as the "Applegate" amphibian, of which only two experimental units were produced. The principal features were unusually low weight and silhouette, drive on the front axle only, steering by rear caster wheels, and plywood hull construction. It was notable more for the unique design than for its performance or stamina, the lack of which resulted in early abandonment of the project.

Our amphibious trucks are not such extremely complicated vehicles, but they do represent distinctly unusual manufacturing problems for the automotive industry. The primary engineering problem which spilled over into production difficulties has been the fabrication of the hulls and their closures. An exposition of the details of design and construction, including the modifications injected into production as the result of service experience, cannot be released at this time, but will make very interesting reading when the situation permits.

Successful amphibian operation requires a thorough understanding by the commander of the limitations of the equipment. It also demands of the operator a basic knowledge of the principles of small-boat handling and detailed training with the particular model to which he is assigned. As land trucks, our standard models are no more difficult to handle than other standard vehicles. They do require special consideration from the maintenance angle, however, and they should not be used as substitutes for the land vehicles except in extreme emergencies.

It is interesting to note the similarity of many of the items of peculiarly marine equipment, controls, and instruments incorporated in these vehicles to those which one would expect to find on aircraft or submarines. In addition to the normal automotive controls, these include such items as: special marine operating instruction plates, ventilator handle, propeller-engaging lever, bilge-pump control levers, pump valve shift levers, deck air intake control lever, air outlet duct control lever, fire caution plate, recording engine tachometer, anchor and cable, and an emergency bilge pump. Surf shields, and many other items too revealing in their nomenclature to permit mention in the present article are also incorporated.

The vision of the dreamers and pioneers of amphibious cars and trucks has been proved well-founded. Ordnance amphibious trucks are proving the practicability of manufacturing this type of hybrid vehicle and the basic soundness of the engineering which has been incorporated in current production models. It is safe to predict that further advances in the art will be made and prove that even the Gargantuan monstrosities which have decorated the covers of certain "penny-dreadful" pulp magazines in the past are not without the pale of possible development and use in the next "war to end all wars." In the meantime, wouldn't the ¼-ton amphibian, even imperfect as it may be today, make a handy outfit for that duck-shooting trip after we finish our present job of world housecleaning?



Signal Corps

Machining Cast Armor Plate

A Discussion of the Tools and Technique Required

Fred W. Lucht

ONE of the difficulties in machining armor-plate castings is that the term "armor plate" of itself provides no definite indication as to the machinability or lack of machinability of an individual casting. Specifications for armor plate are largely based on ballistic requirements and have only slight bearing on the chemical composition or physical characteristics of the material. It is the latter which determine its machinability.

There are, however, a number of general considerations applying to almost all armor-plate castings which require machining. It is the general practice, for instance, to remove the gates by flame cutting, and on some castings an extremely hard, glassy surface is encountered. The second characteristic is that most castings of this type, particularly for tank parts, have irregular contours and thus require interrupted cutting. A third problem is that the casting frequently has scale on some portions. In some cases also, hidden sand pockets and extremely hard inclusions are found to be present in the portion of the casting to be removed by machining.

An outstanding difficulty in machining armor plate is that this naturally tough and hard material has a tendency to "work harden." It is therefore important to use tools which are as free-cutting as possible.

Equipment employed to machine armor-plate castings consists largely of vertical boring mills, vertical turret lathes, and large engine lathes. Prime characteristics required in such machines are that they should be sufficiently rugged to withstand the shock resulting from interrupted cutting and that the drive motor should have ample power to pull the maximum number of tools—particularly when the latter are slightly dull. The power requirements should take into consideration allowances for machining to maximum depth of cut, since some castings have more run-out than others. Horsepower requirements should be carefully checked to see that the machines will not be underpowered. If they are, it may be impossible to secure the combination of cutting speeds, depths of cut, and feeds essential to efficient machining.

If possible, each machine should be equipped with a variable-speed motor drive having a rheostat control or other device to permit varying the cutting speed during a cut. This is a help in maintaining the proper cutting speed for facing cuts on rotating parts. It also permits smooth and rapid speed changing to protect the tools when hard spots or sand inclusions are encountered; otherwise it might be necessary to run the entire cut at a lower speed.

Fixtures should be sufficiently rugged to absorb the vibration and shock resulting from an interrupted cut. Points of location and support should be carefully selected to equalize stock removal, taking into account not only the particular operation in question, but also stock removal in subsequent operations.

IN machining armor-plate castings it is highly desirable, if not essential, to precede fixture design by "planned-cutting" layouts for each casting. In this connection, one of the most useful procedures before machining an armor-plate casting is the preparation—even before actually tooling the job—of a planning chart which will show in detail the cuts to be taken to convert a rough casting to a finished machine part.

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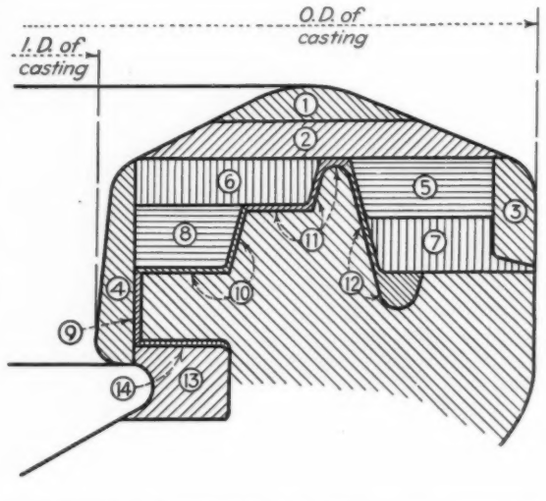
Fig. 1 shows a typical chart of this kind. It includes a section drawing of the finished part superimposed on a sketch of the rough casting. The part shown is not an actual one, but is typical of conditions to be met in machining many armor-plate castings. Note that the chart shows the order of the various cuts while the tabulation indicates the type of tool to be used, where it should be placed on the machine, the revolutions per minute, and the feed required to produce the correct speed-feed relationship, as well as other data. For the sake of clarity, the cut taken by each individual tool is separately numbered, although two or more cuts by two or more tools may be combined in the same operation. This is useful practice since it indicates readily to the operator which tool should enter the cut first.



Cut No.		Use Tool No.	In R.H. or L.H. Head	RPM	Feed	Tool Setting Block No.	Remarks
1	Same Time	D-1234 T-1	L.H.	12	0.015	——	Only necessary when cut is too deep for tool in cut No. 2
2	Same Time	D-1234 T-1	R.H.	12	0.015	D-1234 T-15	
3	Same Time	D-1234 T-2	R.H.	10	0.015		
4	Same Time	D-1234 T-1	L.H.	10			

FIG. 1. DIAGRAM AND CHART FOR "PLANNED CUTTING"

Drawings such as these, with their accompanying cutting instructions, have been found tremendously useful in reducing machining time on armor-plate castings as well as other forms of large castings on which a number of different cuts are required. For instance, with reference to Fig. 1, turning the outside diameter at "3" or boring at "4," before taking facing cuts "5" and "6" will materially reduce the over-all time since the latter are to be followed by two more facing cuts, "7" and "8." Similarly, the finish-boring operation "9" is placed ahead of finishing operation "10." The stock to be removed in operation "12" may be handled by a plunge-type cut.

On most machining operations it is always good practice to start a facing cut ahead of a boring or a turning cut. This enables the facing tool to remove all rough stock and leave clean material in which to start the turning and boring tools. This routine assists in protecting those tools which may have to hold size within definite limitations for the longest time.

Every cut taken after the "first" finishing cut represents waste time. As a matter of fact, a number of light cuts with a depth of only a few thousandths (0.002 to 0.015) of an inch will produce a poorer finish, due to work hardening, than when the finishing cut is 0.045- to 0.060-inch deep. In addition, the multiple light cuts also result in rapid loss in size maintenance because of increased tool wear. A good rule to follow in machining cast armor plate is never to take two or more cuts where a one-pass finish may be satisfactory. When it is necessary to follow a rough cut by a finish cut, leave 0.045- to 0.060-inch stock for finishing. This gives the finishing tool increased life while improving finish and maintaining size much better.

On many vertical boring mills, much valuable time is wasted by the operator taking cuts on a cut-and-try basis to bring an important diameter within specific tolerances after taking the initial roughing cut. This waste time can be reduced materially by providing the operator with an indicating type of gage, enabling him to determine quickly the amount he is off size. By using graduated dials on the machine, he then can quickly make the necessary adjustment for size and take the final finishing cut.

On many vertical boring mills it is possible to use two vertical rams for machining and reduce the over-all machining time where only one ram is normally being used. Fig. 3 shows such a set-up. The tool taking the longest cut is, according to good practice, located in the left-hand ram where its face is not visible to the operator. The tool taking the shortest cut is located in the right-hand ram where the face of the tool is visible. With both tools starting to cut at approximately the same time, the operator now has an opportunity to stop the tool in the right-hand ram after it has completed its cut and before it hits the shoulders on the work, permitting the tool in the left-hand head to go on until it has reached the end of its cut.

Similarly, in Fig. 1, if operations "7" and "8" are performed simultaneously, tool No. 8 should be in the right-hand ram and tool No. 7 in the left-hand ram. Tool No. 8 is started first and then tool No. 7. The operator now watches tool No. 8 to stop the feed when it has reached the finish of its cut and can then turn to watching tool No. 7.

Rules for planning the machining of armor-plate castings cannot be made specific. A layout like that in Fig. 1, however, will quickly reveal in each instance the proper depth and sequence of cuts which will give minimum floor-to-floor time. Frequently, it is found that several operators on as many machines, running three shifts of work on the same job, will vary widely in their floor-to-floor time. This is usually traceable to lack of proper planning and therefore to lack of uniformity in practice.

In making a sketch such as shown in Fig. 1, it has usually been found desirable to make it full size, properly scaling the depths of cut as a help to the operator, especially if the job is new to him. When this practice is followed, it will be found frequently that even greater increases in production are available than through the adoption of carbide tools alone.

It is not always an easy matter to introduce planned cutting in a shop, particularly where the operators are old hands. Here the introduction of a "new" form of tool (car-

bides) is of major assistance in improving general machining practice in the shop.

EXPERIENCE has shown that in selecting tools for the machining of armor plate, best practice is to tool up for use of carbides rather than high-speed steel or other types of cutting material. The rule should be to use carbides wherever possible, since this provides much faster machining, longer tool life, and less down-time for the machines. This is due to the higher resistance to abrasion of carbide tools and their ability to cut at higher surface speeds.

There are times, however, when high-speed steel tools can be effectively used in machining armor-plate castings. On multiple-turning operations where one tool is working on a large diameter and one on a fairly small diameter, it is sometimes advisable to use a carbide tool for the faster speed and a high-speed-steel tool for the necessarily slower speed, thus obtaining maximum advantage from both types of tools. This has been found satisfactory providing the smaller diameter is relatively free from hard spots and inclusions. When carbide tools are used, it will generally be found that parts can be cast closer to size, thus reducing machining time. The reason for this is that carbide tools can finish cut through scale more effectively than can be done with tools of other materials. It might be pointed out also that casting closer to size also effects a saving in vital materials.

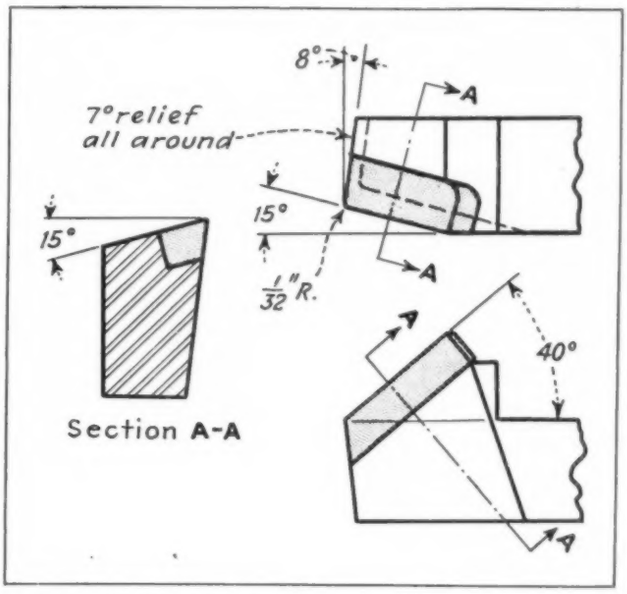


FIG. 2. SHEAR-TYPE TIPPED TOOL FOR ROUGH MACHINING

Of particular importance in the machining of cast armor plate is that tool shapes must be correct and definite for each machining operation to provide maximum speed in cutting, best obtainable finish, and longest tool life. In general, the weakest portion of any carbide cutting tool is the nose radius, and the more protection afforded the nose of the tool the longer usually is the life. This means the proper combination of side cutting edge and back and side rake angles, since these three angles control the protection afforded both the cutting edge and the nose radius.

Where cuts are of an interrupted nature, the tool must be designed to prevent its digging into the cut in any direction and also to absorb backlash in the machine before the nose of the tool enters the cut. Much unnecessary tool trouble has been caused in the past by failure to observe this simple consideration.

From this standpoint, one of the most important developments in connection with the machining of cast armor plate was the introduction of the "shear-type" tool. This tool, shown in Fig. 2, was at one time used quite extensively but had fallen into disuse until reintroduced in several shops by Carboloy engineers. It is performing a real job today in rough machining not only armor plate but also other forms of large castings. It derives its advantage from the fact that, on interrupted cuts, the first contact between the tool and the work is away from the relatively weaker nose of the tool and back along its face. The tool thus enters the cut with a "slicing" action. The gradual entry of the tool into the cut reduces the shock on the carbide tip as well as providing a gradual take-up of backlash in the machine. The tool is not as useful for finishing cuts, since the extreme negative back rake on the tool has a tendency to curl the chip toward the finished surface with a possibility of marring the latter. The shape of the tool limits its use to shanks which are approximately one-inch square or larger in size.

Cross sections of shanks for any single-point tool, as a matter of fact, should be sufficiently large to withstand the bending load resulting from the depth of cut and feed used for a given tool overhang. This means that when a cut is of the interrupted type, either the shank must be larger or the tool overhang must be reduced to protect the tool against the higher impact load. Shank materials may be either SAE 9250 steel (Silman), carbon varieties ranging between SAE 1050 and SAE 1095, SAE 2340, or any low-alloy type.

It should be emphasized that in setting up tools for the machining of cast armor plate, tool overhang should always be kept to the minimum. When the operator is forced to use a tool with too big an overhang, vibration may be set up in its shank, decreasing tool life. This characteristic is readily identified by a singing sound or even chatter of the tool.

IN machining armor plate as in machining any material with carbide tools, it is essential that tools be watched to prevent their becoming excessively dull. A dull tool breaks down rapidly, requiring far more grinding when eventually resharpened than if sharpened before it becomes too dull. Furthermore, it takes more power to machine with a dull tool than with a sharp one. Unless properly instructed, some operators will continue to work with dull tools until the machine finally stalls due to insufficient power. There is little excuse for this sort of thing since the chip itself will tell the story of whether or not the tool is sharp. The appearance of streaky discoloration or a reddish color is almost always an indication that the tool needs sharpening. With a perfect cutting edge the chip is uniformly silvery. A straw-colored band appearing on the rough surface of the chip means that the cutting edge is breaking down. This band runs in the direction of the chip flow.

Two different methods of procedure are recommended when a machine accidentally stops with the tool in the cut. If the tool is accessible or will not drop if loosened, disconnect the feed, loosen the clamp screws, remove the tool, and examine it before starting the machine. If the tool is not accessible or will drop if loosened, disconnect the feed before starting the machine.

As a matter of fact, whenever it is desired to stop a cut, the *feed* should always be thrown out *first,* allowing the tool to free itself in the cut before the machine is stopped. Moreover, when the cut is of the interrupted type, the operator should try to stop the machine with the tool in an open space *after* throwing out the feed.

The grinding of tools is a specialized art and can be performed most quickly and accurately by men whose sole job it is, day in and day out, to grind tools to required dimensions and tolerances. While correct grinding may take a little longer than incorrectly grinding a tool, the difference in life between grinds when machining armor-plate castings is such that the average grinding time per piece produced is considerably less for the correctly ground tool.

Whereas 25 to 30 feet a minute is an average maximum for machining with high-speed-steel tools, no difficulty is usually encountered in using speeds of 150 to 250 feet a minute when cutting with carbide tools on continuous cuts. Actual speed depends on the machine and work conditions. The cleaner the material and the better the condition of the machine, the higher the possible speed. Best practice on continuous cutting is to start around 150 feet a minute and increase the speed until the best machining time has been obtained without creating other difficulties. More care should be taken to prevent underspeeding than overspeeding when machining with carbide tools. Even on interrupted cuts it is questionable whether speeds of less than seventy-five feet a minute should be used, since the lower speed and the high chip pressure on the cutting edge may cause rapid tool breakdown. If higher speeds are not available on the machine it may be better to use a high-speed-steel tool at twenty-five to thirty feet a minute. It is frequently noticed when facing interrupted cuts that the finish is poorer toward the inside diameter. This is another evidence of underspeeding since the tool, as it approaches the smaller diameter, is cutting at a lower and lower speed. The best procedure here is to provide the machine with a rheostat by means of which the work speed can be increased as the surface speed is reduced (see Fig. 4). Such a control not only quickly improves machining conditions, but also reduces the over-all machining time and helps to save the tool.

When machining interrupted cuts, it is recommended, in general, that the starting feed should be around 100 feet a minute with a "normal" range of 90 to 150 feet. A rheostat control here would permit reducing the speed if the casting is found to be bad after starting the cut. As soon as the material becomes cleaner, the speed can be again increased to 100 or 150 feet a minute. To determine when it is desirable to reduce the speed, it is necessary only to listen to the sound of the chip. In machining armor plate, the chip should come off with a characteristic "whistle." When a hard spot is encountered, the tone changes.

In machining cast armor plate it is usually desirable to use as deep a cut as possible, compensating for extremely heavy depths of cut, if necessary, by using relatively light feeds. In roughing, the best practice is to cut to within one-sixteenth of an inch of the finished diameter or face, thus "sinking" the roughing tools as much as possible. Cuts as deep as three-fourths to one inch have been taken effectively with carbide tools. As a matter of fact, carbide tools seem to stand up even better with deep than with light cuts because the pressure is distributed over a greater length of the tip.

On interrupted cuts, the advantage of burying the tool to the maximum depth of cut and reducing the feed if necessary is even greater than on continuous cuts. Tool life will be better under such conditions than if the depth of cut were equivalent to the nose radius or even less. The reason is that the shock of the interruption is removed from the nose end of the tool, and first contact between the tool and the work after each interruption is located farther back toward the end of the tip where the strength is greater. When the tool hits a sand pocket or hard inclusion, a deep cut will insure the tool being buried in clean material to steady it while cutting. Furthermore, the tool will not be as free-cutting, if the nose radius or less is buried in the cut, as it will be if a greater portion of the side cutting angle is also cutting.

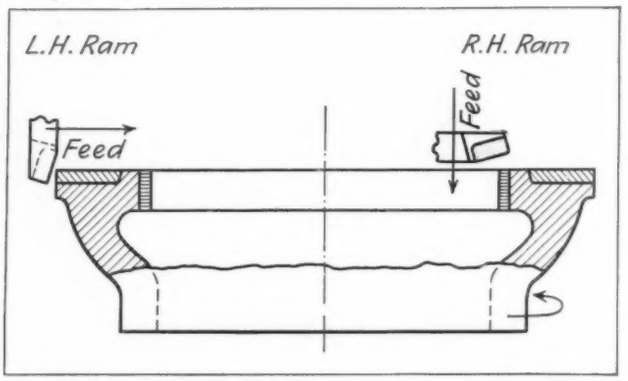


Fig. 3. Use of Both Rams on a Vertical Boring Mill

In machining interrupted cuts it is desirable to leave at least one thirty-second of an inch for finishing. Cast armor plate is somewhat springy and has a tendency to distort to some extent during the roughing cut. Leaving one thirty-second to one-sixteenth of an inch for finishing enables cleaning up to correct specifications.

As to feed, a good average is around 0.015 per revolution. Where there is considerable impact on the tool it may be desirable to reduce this to 0.010 per revolution. However, a reduction in tool life is often caused by too light a feed, the light feed tending to increase the abrasive action between the tool and the work at the point of entry of the tool into an interrupted cut. There is also increased abrasion between the light chip and the tool. This condition is particularly to be guarded against on machines having considerable backlash. In general, the larger the cutting-edge angle the greater the feed which should be used. Tool life is usually increased with higher feeds.

However, it is frequently possible to use a feed of 0.010 to permit finishing of the casting in a single pass—particularly where surface finish is not of vital importance. Best practice to follow is to start with a fairly small feed and then increase it until the set of conditions is encountered which will give the best combination of machining time and degree of finish. As a matter of fact, it is frequently possible, where finish is not too important, to use a higher feed for finishing than for roughing.

Considerable trouble frequently can be avoided on old vertical boring mills by reducing all feeds at least fifty per cent through the use of change gears. Some of these old boring mills—as well as a few of the new ones—have mini-

mum normal feeds of 0.025 to 0.031. This feed is frequently somewhat too high when machining interrupted cuts.

A point to be guarded against when armor-plate castings have a considerable runout is reducing the feed too much. This is true also when hard spots are encountered. If too small a feed is used in such cases, the tool has a tendency to "ride" the cut. Here it is better temporarily to reduce cutting speed, as previously mentioned.

When taking facing cuts, it is usually desirable to start the cut at the outside diameter and feed toward the center. This permits the use of standard tools. If a tool has to be fed outward from the center, a special tool with increased relief behind the cutting edge is required to insure free cutting.

General indications are that longer tool life is obtained by cutting armor plate castings dry. It is frequently necessary, however, as on parts where accurate size is of prime importance, to use a coolant to prevent the casting from absorbing the heat of the roughing cut and thereby distorting the casting in the fixture. Sometimes a coolant also should be used when finish machining to prevent the possibility of a dimension being to size while the work is hot and then shrinking undersize when it cools off. The loss of time resulting from the necessity of waiting for a casting to cool after rough machining is also a consideration in whether or not a coolant should be used.

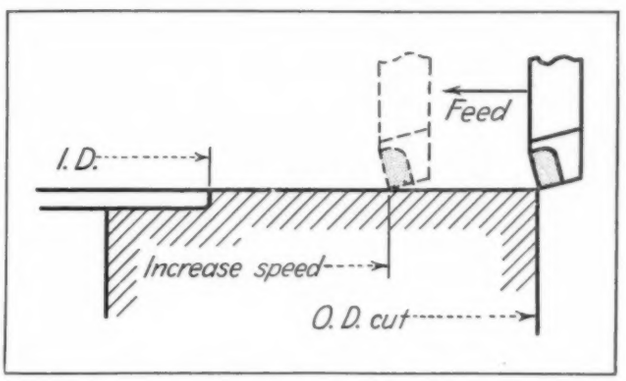


FIG. 4. TABLE SPEED INCREASED AS TOOL NEARS CENTER

If a coolant is used for this purpose, however, it should not be directed against the tool or allowed to splash against it, but should be directed whenever possible against some major portion of the casting to keep the work itself cool. Where limitations make it necessary to direct the coolant to a point on the casting near the tool, a high-velocity stream of coolant should be used, directing it at both the face of the tool and the curling chip. A properly cooled chip will have a silver color. If coolant must be used, a solution of soluble oil as furnished by any of the leading cutting-oil manufacturers is recommended.

CONTRARY to usual practice in the machining of steel with carbides, chip breakers incorporated in the tools are usually undesirable in machining cast armor plate. The only time when chip breakers should be used is when the chip becomes a hazard to the operator, ruins the finish, or has a tendency to spoil the tool. The reason for this is that chip pressure is extremely high and chip breakers in themselves tend to increase the pressure on the cutting edge and reduce tool life. If chip control must be built into the tool, a chip curler rather than a chip breaker should be used, and these should be designed so as to coil the chip loosely; the tighter the coil, the greater the pressure. Tight curling becomes particularly troublesome where castings have hard spots. These hard spots in themselves tend to curl the chips tighter. Chips should never be broken into short lengths. A short chip may raise loads up to a point where the machine actually kicks out, stalls, and breaks tools. It is rather remarkable to note the extent of this increase in loading. We have seen heavy machines stall where a lighter machine would take the same cut without difficulty just due to the use of a chip breaker which had a tendency to choke the chip.

On interrupted cuts, chip breakers frequently can be forgotten entirely since no objectionable or dangerous hay-like chip is formed as may be the case with continuous cuts. If a chip curler is required for an interrupted cut to control the chip between interruptions, the curler should be of maximum width. On continuous cuts on armor-plate castings it is sometimes difficult to control the chip if the casting is in poor condition making it necessary to run at slow speeds. This type of chip is almost impossible to break. It is preferable to coil it loosely in coils of about 1¼ to 1½ inches in diameter. When this is done one of three things usually will happen: (1) the coil will eventually hit the work and break off; (2) it will hit some part of the fixture, chuck jaws, or chip bank and break off; (3) it will drop because of its own weight. Many times a flow of coolant directed against the chip will simplify the problem of breaking it.

One of the hazards of coiling chips too tightly is that a high pressure is built up, and when the chip snaps away from the cut it usually flies off at a rather high velocity, becoming a real danger to the operator or any one else near the machine. When negative rake angles (either back or side rake, or both) are used, there is a decreased tendency toward a chip problem, since a tool so designed will direct the chip against the unformed portion of the cut and break it. If it fails to do so at one feed, proper chip breakage may be restored by increasing the feed slightly.

When chip curlers have to be used, too much emphasis cannot be placed on the importance of properly regrinding the curler when sharpening tools. It is not unusual to find that a tool which has been operating quite satisfactorily before regrinding will tend to break down rapidly after sharpening due to improper procedure in grinding the chip curler. In this connection the operator should be cautioned against using worn-out diamond wheels for grinding chip curlers. It is almost impossible to grind a correct curler with a worn wheel.

A volume could be written on selection of correct angles in machining cast armor plate. Negative back rake has been found highly advantageous in many applications as previously mentioned. With such tools, the tip is below the center, reducing the amount of front clearance necessary for straightening the tip by providing more shank support under the nose. Where considerable hard inclusions and sand pockets are encountered, it is frequently desirable to provide a small amount of negative back rake where cuts are continuous. This has a tendency to protect the nose of the tool. General indications are that for interrupted cuts, side-rake angles of between five degrees positive and three degrees negative insure the best tool life. The larger positive angle improves free cutting action. Negative angles are best when the work is hard and scaly and contains hard inclusions and sand.

Signal Corps

The Caliber .50 Machine Gun

It Has Proved the Outstanding Machine Weapon of World War II

Brig. Gen. James Kirk

FOR more than a year the Army Air Forces have been heavily engaged in Europe, in Asia, and in Africa. During this time, reports have appeared almost daily in the newspapers of fierce fights between American bombers and pursuit ships and Axis aircraft in which large numbers of enemy planes have been shot down. The results obtained reflect credit on the planes, on their crews, and on the guns and ammunition employed. The caliber .50 aircraft machine gun, with which all our successful types of bombardment aircraft are armed, has been especially noteworthy for its performance.

During World War I, most combat aircraft were armed with rifle-caliber machine guns. Toward the end of the war, a start was made in the development of a caliber .50 machine gun since a heavier-caliber weapon was desired for greater destructive effect against ground and aërial targets. Postwar development led to the adoption of the caliber .50 Browning aircraft machine gun, M1921, initially designed for timed firing between the propeller blades of fighter airplanes. Its principle of operation was substantially the same as that of the caliber .30 water-cooled Browning machine gun, M1917, which was used toward the end of World War I by our troops in France. Of course, there were very substantial differences between the two weapons because of the much heavier cartridge employed in the caliber .50 gun.

After the development of the caliber .50 aircraft machine gun was completed, a water-cooled gun of that caliber for antiaircraft use was developed and standardized as the caliber .50 water-cooled Browning machine gun, M1921. The aircraft and water-cooled models, M1921, had substantially the same working parts except for the barrels and barrel jackets; however, their use was somewhat restricted because the ammunition belt had to enter each gun on the left side. Consequently, symmetrical installations of multiple guns could not be made. Also, a need had developed for an air-cooled caliber .50 machine gun having a barrel definitely heavier than that of the aircraft gun so that a larger number of shots could be fired through it before serious loss of accuracy caused by expansion of the bore of the barrel from heating would result. Furthermore, experience with the M1921 models showed the desirability of making certain minor improvements in the guns. Therefore, the caliber .50, M2, model was developed and standardized in 1933.

There are three main types of caliber .50, M2, machine guns; namely, the M2 caliber .50 aircraft machine gun—the most important one—which was given prime consideration in all phases of design, the M2 caliber .50 water-cooled machine gun, and the M2 caliber .50 heavy-barrel machine gun. All these guns can be mounted in the same mount, and any of them can be changed over in a minute or so to take the ammunition belt from either the right or left side without additional parts. By changing barrels, barrel jackets, and minor components, any of these three types can be converted to either of the other two. Thus, the utmost in the interchangeability of the important parts of the guns is obtained, greatly facilitating mass production with the same tooling setup.

THE M2 caliber .50 aircraft machine gun is today the most important aircraft weapon used by the Army Air Forces. Its high rate of fire (800 shots a minute) combined with its powerful striking effect and long range (it outranges the 20-mm. cannon used by the Axis), explains why it has accounted for so many hundreds of Axis planes in World War II. This gun is one of the few weapons used by all our armed services alike. In addition to its employment as an

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aircraft gun by the Army Air Forces, the caliber .50 is used by the Ground Forces as an antiaircraft-antipersonnel weapon and, with armor-piercing ammunition, against light tanks and armored cars. It is employed by the Navy, Coast Guard, and Marines for aircraft, ships, and landing forces, and is the chief antiaircraft weapon on our merchant ships. The illustration on page 564 shows a caliber .50 water-cooled antiaircraft machine gun being used against attacking tanks.

Since the gun is so good as an aircraft weapon, the Army Air Forces, the Bureau of Aëronautics of the Navy Department, and aircraft manufacturers making war planes have exercised much inventiveness in mounting the caliber .50 Browning gun in aircraft. For this reason, more than a dozen of these lethal weapons make it almost certain death for any Axis fighter plane to approach the Flying Fortress from any angle. Marvelously designed machine-gun turrets carrying twin .50's which can be operated by a twist of the gunner's wrist are located in the underside, the top, and the tail of this superb flying machine. The mounts include a scientifically designed computing sight which cuts to a minimum the judgment which must be exercised instinctively by the gunner in hitting an attacking plane, no matter what its speed or angle of approach.

During the Coral Sea battle in which such heavy damage was done to the Japanese fleet, a lone Navy pursuit ship, which had become separated from the other planes in its flight during a dogfight with Japanese planes, was returning to its carrier when the pilot spied a Nip destroyer plowing along through the waves at high speed. The Navy flier decided to take the destroyer on. He darted at the ship and made two runs over the vessel, spraying its superstructure with his caliber .50 Browning machine guns. These two passes incapacitated every one visible on the ship. He then leisurely circled the destroyer, firing into the sides of the vessel. When his supply of ammunition was exhausted, he flew home, leaving the destroyer motionless in the water and leaking steam and oil from hundreds of holes. It is quite probable that this destroyer was sunk.

Good use also has been made of caliber .50 water-cooled and caliber .50 heavy-barrel guns by our armed forces. Many an enemy dive bomber and strafing fighter plane has been shot down by Marine and naval gunners with these weapons. In the Solomons on one occasion the Marines surprised a Jap transport column that appeared to consider itself out of machine-gun range and shot it up with water-cooled caliber .50 Brownings. The heavy slugs smashed up the Jap trucks and made the Jap soldiers who were hit by them look as if they had been run over by the trucks. During the initial phases of the landing operations in North Africa, when strong opposition was put up by the Germans against American landings, several multiple-mounted heavy-barrel water-cooled guns chalked up scores of a half dozen German planes knocked down apiece while they were on landing barges or just after reaching the shore.

SINCE there are hundreds of thousands of these guns now in action against the enemy, it will be appreciated that the problem of supplying spare parts to replace those that wear out in action is a substantial one. However, as most of the important parts in these guns which require replacement are identical in the aircraft, water-cooled, and heavy-barrel types, the number of items of spare parts which must be stocked by Ordnance depots in the theaters of operations is a minimum. If antiaircraft troops, for example, find themselves short of important spares, they can obtain the needed parts from nearby air bases out of stocks kept on hand to meet the requirements of aircraft squadrons armed with aircraft .50's. Needless to say, this feature of interchangeability of parts among all types of caliber .50 M2 Browning guns saves millions of dollars in stocks of parts which would otherwise have to be established to take care of different types of caliber .50 guns.

The value of the large measure of interchangeability of parts among the various types of M2 Browning machine guns has been demonstrated repeatedly in manufacture. Changes in requirements for machine guns made it urgent on several occasions that water-cooled and heavy-barrel guns be manufactured by plants producing aircraft guns. With a minimum of delay, these plants changed over to the manufacture of these types and, when the emergency had been met, swung back to the aircraft-type gun. So the outstanding manufacturing advantages of the M2 design parallel its advantages in coping with problems of supply and maintenance in the field.

U. S. Navy

A BATTERY OF WATER-COOLED CALIBER .50 ANTIAIRCRAFT MACHINE GUNS ABOARD A NAVY AIRCRAFT CARRIER

The "Bazooka" Antitank Rocket Launcher

Above is shown the famous Ordnance-developed "Bazooka" which launches a rocket projectile, shown below, capable of stopping any enemy tank. The launcher is a metal tube, abou 50 inches long and less than 3 inches wide, open at both ends. The weapon is operated by a 2-man team. An electric battery sets off the rocket charge (Signal Corps photos).

Ordnance Research and Development

The Department's Coördinated Program Assures Superior Weapons

Col. William A. Borden and Capt. Robert Kramer

"WHAT comes most clearly out of the dispatches is the sterling worth of American Ordnance." This outstanding tribute to our arms came from a London newspaper, the *Observer,* Sunday, May 9, 1943, upon the triumphant conclusion of the North African campaign. Such unstinted praise is by no means unique. From all quarters have come similar commendations for the matériel developed and produced by the Ordnance Department and used by American and allied soldiers on battle fronts throughout the world. Behind this success of Ordnance weapons are many fascinating tales. One of the most interesting of these is the story of how our Ordnance development is always marching forward at a continuously accelerating speed, bringing to our armed forces weapons of increasing excellence and superiority.

In recent years, the activities of the Ordnance Department have grown by such leaps and bounds that today its research and development program is one of vast proportions. Since 1940, over 1,700 items incorporating more than 300,000 principal components of small arms, artillery, ammunition, aircraft armament, and tank and automotive vehicles have been put into production. During the same period, several hundred entirely new weapons have been both developed and introduced into manufacture. Today there are over 1,000 new weapons under development and undergoing tests preparatory to final approval and potential standardization for production.

The development and standardization of new and improved types is and must be a never-ending process in order to keep ahead of our enemies. Consequently, the final standardization for production of new items and the initiation of development and tests of other new items is a daily occurrence in the Ordnance program. In addition to all the foregoing activity, there is a broad and thorough basic research program in all scientific fields affecting ordnance, which is being conducted by basic research organizations of all types.

To carry on such a truly gigantic program the Ordnance Department of necessity has been and is continually utilizing the scientific and technical resources, men, and facilities of the entire Nation—those of the armed forces, of other Government agencies, and of private industry. A brief description of the organization of the Ordnance Department and of the Army will reveal the extent to which the Department has mobilized such resources for research and development.

One of the four chief divisions of the Ordnance Department is the Technical Division, headed by Maj. Gen. G. M. Barnes. This division has responsibility for carrying out forward-looking programs of research and development of new and improved matériel and of new and improved materials for Ordnance use. Within the Technical Division there have been established branches dealing respectively with small arms, artillery, aircraft armament, and ammunition; all the research and development activities of the Ordnance Department on these combat materials are handled by these branches. Within the Technical Division there is also a Tank and Motor Transport Development Liaison Branch which has the responsibility of supervising, directing, and coordinating the work of the Development Branch of the Tank-Automotive Center at Detroit, Mich., which handles the development of tanks and automotive vehicles, under the command of Brig. Gen. Walter P. Boatwright. The development of such matériel has been delegated to the Development Branch of the Tank-Automotive Center in order to take advantage of the close association with the superb facilities for this work at Detroit. This arrangement of branches in the Technical Division results in both concentration of effort in respective fields of Ordnance and efficient and prompt development of all ordnance matériel.

A SIXTH branch of the Technical Division—the Service Branch—has related and important functions. In the research section of this branch there is centralized the administration of all contacts with the basic research projects affecting Ordnance assigned to the National Defense Research Committee. In addition, a separate unit of this section coöperates with the National Inventors Council in reviewing inventions affecting Ordnance submitted to the Government. These two important activities of the research section will be described subsequently in more detail. The research section also supervises and coördinates the activities of all the Ordnance research laboratories located at our various arsenals and proving grounds. Another section in the Service Branch directs and supervises all ballistic activities and ballistic research in connection with ammunition, small arms, and artillery, including those of the excellent ballistic research laboratory at the Aberdeen Proving Ground.

The materials section of the Service Branch administers the preparation of all Ordnance specifications and has undertaken the highly important conservation work of saving strategic and critical materials. The Service Branch also provides certain special services of experts in connection with work on armor plate, plastics, lubricants, and similar materials. Finally, the Service Branch, through its development-analysis section, follows the progress of all research and development undertaken by the Ordnance Department and renders periodic reports and analyses of the progress being made. This latter section also administers the collection and examination of captured enemy matériel for significant technical information about enemy weapons.

The Technical Division administers and directs the proving center of the Aberdeen Proving Ground where development and acceptance testing of all types of ordnance equipment is undertaken. Moreover, to aid in evaluating the performance of ordnance matériel undergoing development and, in particular, to insure that such matériel will operate under temperatures and climatic conditions peculiar to various regions, technical testing detachments have been located in the desert country of the Southwest and in the north of Canada.

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These detachments, under the direction of the Technical Division, supplement both the testing carried out in weather normally found at Aberdeen and also that performed in artificial conditions created at Aberdeen in hot and cold test rooms, for Ordnance equipment must be made to function perfectly both in the desert under the scorching sun and in the north under arctic conditions. In addition, in order to test tires, bogie wheels, and other rubber-using motor parts, a fleet of vehicles is continuously operating over test courses in Texas under the direction of the Development Branch of the Tank-Automotive Center. In this manner, the introduction and use of synthetic rubber for such matériel is daily being evaluated.

THE work of the Technical Division is closely coördinated with and continually assisted by the three other main divisions of the Ordnance Department. The Industrial Division, the second main division of the Ordnance Department, has charge of procurement, production, and inspection of ordnance matériel and exercises its functions through its own manufacturing establishments and through the industrial facilities mobilized by it in the various Ordnance procurement districts. In addition, this division has charge of engineering in connection with the improvement of production processes and of existing Ordnance equipment from the production standpoint. For this type of work the division has established "integration committees" composed of representatives from industries whose splendid work will be referred to later. Maj. Gen. Thomas J. Hayes is chief of the Industrial Division.

The Military Training Division, headed by Brig. Gen. Harry R. Kutz, handles the training of Ordnance troops at reception centers, schools, and training centers. The Field Service Division, headed by Brig. Gen. Julian S. Hatcher, is responsible for the storage, maintenance, surveillance, and renovation of ordnance matériel, and the issue of such matériel to troops. This division receives the matériel developed by the Technical Division and produced by the Industrial Division and operates with the men trained by the Military Training Division.

All the functions charged to these four main divisions peculiar to tank and motor-transport vehicles have been delegated to the Tank-Automotive Center at Detroit to provide appropriate means of efficiently conducting Ordnance automotive activity at the heart of the motor industry. Various functions of this center are charged to branches which parallel in their activity the operations of these four divisions.

Each of the main divisions of the Ordnance Department and their manifold agencies are continuously on the alert within their respective fields of operation for any requirements for new or improved equipment and constantly bring to the attention of the Technical Division all requirements for research and development to satisfy such needs. All the main divisions of the Ordnance Department work together as a team, being coördinated through their respective chiefs under the direction of the Chief of Ordnance, Maj. Gen. Levin H. Campbell, Jr.

The Ordnance Department is part of the Army Service Forces, formerly known as the Services of Supply. The Army Service Forces, commanded by Lieut. Gen. Brehon B. Somervell, has assigned to it all basic supply and technical functions and responsibilities of the Army—exclusive of those pertaining to the Army Air Forces—and includes, besides Ordnance, the other technical and administrative services of the Army, such as the Signal Corps, Medical Corps, Corps of Engineers, Quartermaster Corps, and Chemical Warfare Service. The research and development work of all these services is coördinated and supervised by a research and development branch at the headquarters of the Army Service Forces.

The Army Service Forces constitute one of the three chief divisions of the War Department. The others are the Army Air Forces and the Army Ground Forces. The research and development activities and needs of the Service Forces, Ground Forces, and Air Forces are all carefully coördinated and mobilized. Thus, in the field of Ordnance there has been established the Ordnance Technical Committee under the chairmanship of the chief of the Technical Division. This committee, meeting weekly, reviews all research and development projects of the Ordnance Department and advises the Chief of Ordnance on all matters affecting such projects. All items of Ordnance which are adopted as standard for use by the armed forces are considered and approved by this committee before adoption. All the technical services of the Army Service Forces, such as the Quartermaster, Signal Corps, Corps of Engineers, Chemical Warfare Service, and Medical Corps, have members on this committee who, by giving the Ordnance Department the benefit of their suggestions on research and development, serve to coördinate the research and development work of their respective branches with the work of the Ordnance Department.

In addition, the various arms of the Army Ground Forces —such as Coast Artillery, Armored Forces, Field Artillery, Tank Destroyers, Infantry, Cavalry, and Antiaircraft Artillery—each have a representative on the Ordnance Technical Committee to make known their needs and their suggestions on research and development. Moreover, on all the service boards of these various arms of the Army Ground Forces are Ordnance Department representatives whose activities and reports serve to coördinate the work of the Ordnance Department with the requirements and ideas of the Ground Forces. Thus, the line viewpoint on the development of new matériel is brought directly to the Ordnance Department from the users of such matériel.

FINALLY, representatives of the Army Air Forces are members of the Ordnance Technical Committee and thus insure coördination in the research programs of the Ordnance Department and of the Air Forces. In addition, the Aircraft Armament Branch of the Technical Division maintains close association with Wright Field, where the research and development activities of the Air Forces are centered, in order to secure direct liaison between the experiments and tests of the Ordnance Department on aircraft armament and all related activities and needs of the Army Air Forces.

An outstanding, but by no means unique, example of the services rendered by the Ordnance personnel who work with the arms of the Ground Forces and with the representatives of the Air Forces, is that of the Ordnance officer at the Air Forces proving ground who was the instigator of the technique of masthead or skip bombing which was so effectively employed by the Air Forces in the decisive battle of the Bismarck Sea. His achievement was recognized recently by the award to him of the Legion of Merit.

The Army and Navy are coöperating in research and development in an extremely effective manner. Representatives of both the Navy and Marine Corps are members of the Ordnance Technical Committee and thus receive full

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information about the research and development activities of the Ordnance Department and make known to the Department the related activities of their forces. Moreover, there exists direct communication on an informal basis between corresponding branches of the Technical Division and of the Navy Department in regard to all research activities.

Also, approximately once a month joint meetings are held between the branch chiefs and other personnel of the Technical Division and the chiefs of the Research and Development Division, Naval Bureau of Ordnance, in order to obtain further coördination between the two services. At these meetings, all projects of the Ordnance Department and of the Navy for research and development are described, reviewed, and discussed. In addition, the Technical Division and the Navy exchange complete information with regard to the facilities, personnel, technical reports, projects, and new developments of each service so that at all times each is fully aware of the research work being performed by the other and of the facilities and personnel engaged thereon.

Observers of the British and Canadian Governments are also present at all meetings of the Ordnance Technical Committee in order to give the committee the benefit of their suggestions and to coördinate the research programs of all these Governments. New weapons of these allies are generously made available to the Ordnance Department for experiment, test, and comparison with the performance of American weapons. In addition, the Russian Government also has sent matériel to this country for study and analysis by the Ordnance Department.

In order to utilize as far as possible the technical and scientific discoveries of our enemies, the Technical Division, through the Ordnance intelligence unit of the development analysis section of the Service Branch, receives and studies intelligence reports pertaining to the analysis and examination of all foreign matériel. Its own representatives also have been sent to eight world battle theaters to obtain directly from these representatives reports on enemy matériel. These representatives collect, record, and send shipments of suitable captured matériel to this country for study and analysis, either on their own initiative or as the result of specific requests from the Technical Division. In addition, these and other observers report directly on the performance of the matériel of the Ordnance Department and of our allies under battle conditions in these theaters of war.

If by such methods there is discovered something better than the Ordnance Department has evolved, then such matériel, be it from friend or foe, is immediately copied, with improvements wherever possible, by the Ordnance Department. "Pride of authorship" is never allowed to stand in the way of supplying our armed forces with the best of weapons, regardless of origin.

THE Ordnance Department is also utilizing to the maximum extent the scientific and technical resources of private industry and individuals and of other Government agencies. Material and indispensable aid is given the Department by the industrial facilities mobilized by it. The Department now has in operation over 1,000 contracts with almost 400 laboratories, engineering organizations, and industrial companies for research and development work on ordnance matériel. These contracts have been placed with large and small industrial facilities, profit and nonprofit research groups, and public and private research institutions, universities, and laboratories.

In this way the Ordnance Department has formed a highly successful partnership for research and development work with engineers and scientists in industry and in research laboratories. The organization of industry for research and development has been effectively combined with that of the Ordnance Department, and the unique abilities of each are utilized to the fullest possible extent and in the closest cooperation with those of the other. It is this partnership of the Ordnance engineer and the industrial engineer and scientist—working together as comrades on a team in the way so truly American and so unique to democracies—which has designed, developed, engineered, and put into

production new weapons so speedily and of such tremendous superiority that the enemy, in the words of one correspondent, has been not merely astounded but "terrorized."

In addition, the thousands of Ordnance contractors engaged in the production of standard ordnance matériel have been mobilized, through the industry integration committees administered by the Industrial Division, to work continuously on the improvement of production designs and the methods of production of ordnance. Each of these committees handles a specific group of Ordnance items in an effort to intensify the work on improving design and manufacture from a production standpoint.

At present there are over 85 such committees with approximately 1,000 members meeting periodically, exchanging technical information, and making suggestions for expediting production and reducing costs. In addition, each committee arranges for the manufacturers to visit each other's plants in order to study and compare production and engineering methods and thus to combine the skills and ideas of the entire group. These committees are the successors of technical engineering committees established by the Ordnance Department early in 1940 which met periodically to review and discuss engineering phases in the production of ordnance matériel during the early transition period.

THE industry integration committees have contributed tremendously to conservation of critical materials and savings of millions of man-hours of machine labor. Their work in this field and in other related activities has received valuable assistance from the seven special technical advisory committees established by the Technical Division, each of which is composed of leading experts in technical fields in which important problems to be solved exist. These seven committees are now working on such problems in connection with corrosion, paints, armor-piercing projectiles, ballistic research, and ferrous and nonferrous metallurgy.

This important work has been powerfully implemented by the committees established by leading professional societies and industries to work on such problems with the Ordnance Department. Several of these professional committees have undertaken by contract highly important research and development work for the Ordnance Department. A typical example of a committee of this type is the Coöperative Research Council organized by the American Petroleum Institute and the Society of Automotive Engineers to deal with problems of lubrication and oils. Another such committee is the Ordnance Advisory Committee of the S.A.E.

The chief of the Technical Division also has available the services of an outstanding group of consultants drawn from industry and private life, including such persons as: Dr. C. F. Kettering, General Motors Corporation; Fred M. Zeder, Chrysler Corporation; Dr. F. B. Jewett, American Telephone and Telegraph Company; Dr. William D. Coolidge, General Electric Company; Dr. F. Sparre, E. I. du Pont de Nemours & Company; C. L. Bausch, Bausch & Lomb Optical Company; Edgar C. Bain, United States Steel Corporation; R. Furrer, A. O. Smith Corporation; and Col. H. W. Alden, Timken-Detroit Axle Company. The entire research and development program of the Ordnance Department is reviewed with these consultants periodically and their advice is then obtained on ways and means of extending and expediting this program by including any and all agencies, personnel, and facilities—public or private—capable of assisting the Department.

Many agencies of the Government are being utilized by the Ordnance Department in order to obtain a complete mobilization of the technical and scientific resources of this country for military weapons. The National Inventors Council of the Department of Commerce has given the Ordnance Department access to the suggestions of the general public for new or improved methods of production and for new or improved war weapons. Several of the consultants of the chief of the Technical Division are members of this council and coördinate its work personally and directly with the Technical Division. In addition, there is a unit of the research section of the Service Branch of the Technical Division which coöperates directly with the council in reviewing all inventions submitted to the council which the council deems worthy of further study by the Ordnance Department.

OF approximately 152,650 inventions submitted to the council and reviewed by it as of July 1, 1943, over 50,375 pertained to Ordnance items, of which 1,597 were referred by the council to the Ordnance Department as worthy of investigation. Of these, six have been approved and are now in production, and about fifty-nine are being tested and developed. Moreover, whenever a specific need arises in our armed forces for a new type of weapon, the Ordnance Department requests the council to review its files and submit to the Department all ideas received by the council relating to such a weapon. In this manner, constant and repeated review is made of all ideas submitted to the council.

The Ordnance Department also has mobilized the millions of employees of its contractors for a research and development program. Each of the thirteen Ordnance district offices located throughout the country has set up a distinct organization to stimulate and receive suggestions from each and every employee in the plant of each and every Ordnance contractor. The Chief of Ordnance has sent a personal letter explaining this program directly to every contractor and has provided forms on which the suggestions may be outlined and submitted. Over 108 persons in the Ordnance district offices are now reviewing the suggestions received. As of July 10, 1943, of the 2,756 suggestions received by the Office of the Chief of Ordnance, 2,207 had been reviewed, and 1,109 of these had been adopted and put into operation. When such suggestions are adopted, the originators are recognized publicly with citations or other suitable awards.

In addition, the Ordnance Department continually receives directly from members of the Army and from civilian employees of the War Department inventions or discoveries for consideration as to patentability by the Government. Such inventions, whether or not patented by the Government, are reviewed by the Technical Division, and all those having merit are tested and developed.

In view of the many well-organized and widely publicized programs outlined above for stimulating contributions, and in view of the fact that in every case a worthy idea or invention reaches the agency with experienced personnel capable of evaluating its practical possibilities and with funds to develop and test it, there exists no reason why any meritorious idea or invention contributing to the war effort should fail of recognition, development, and practical utilization. The aim of the Ordnance Department is to supply our troops with the best weapons irrespective of where the ideas for such matériel originate.

The National Defense Research Committee of the Office of Scientific Research and Development has worked closely

with the Ordnance Department for almost three years upon the development of new weapons and has secured for the work of the Department the services of eminent scientists and technicians and the help of outstanding civilian laboratories, bringing together civilian and military talents, skills, and experiences. A unit of the research section of the Service Branch is devoted exclusively to the basic research projects affecting Ordnance under the direction and supervision of the National Defense Research Committee. As of July 1, 1943, of the 546 projects initiated by the committee for the Army and Navy, 147 had originated with the Ordnance Department. Of these 147 projects, 98 are still active. Twenty-three of these projects were undertaken by the War Metallurgy Committee of the National Academy of Sciences which is giving the Ordnance Department valuable assistance on metallurgical problems by making available the skills and resources of the preëminent metallurgists and laboratories of this country.

The Ordnance Department and the Office of the Rubber Director are coöperating closely and effectively in a comprehensive program for the elimination and conservation of rubber in ordnance matériel and the development and adoption of synthetic rubber for such matériel. Frequent conferences and informal discussions on such matters are held between representatives of the two agencies. In addition, reports of all action taken by the Ordnance Department in this field are regularly furnished the Office of the Rubber Director. This excellent coördination in the efforts of these two agencies in this program is resulting in many striking achievements.

The Office of Production Research and Development of the War Production Board also has initiated several projects for the Ordnance Department in connection with the development of basic materials and basic processes. This office supplements the substantial and fruitful work of the Ordnance Department in conjunction with industry in obtaining maximum use of mechanisms, materials, processes, and inventions in war production. The Ordnance Department, industry, and the War Production Board thus conduct and promote research in both production technology and the use of substitute materials and improved industrial processes.

In connection with explosives, the Bureau of Mines of the Department of Interior has worked with the Ordnance Department on a number of projects. The National Bureau of Standards also is continually furnishing to the Ordnance Department technical and scientific assistance of the most valuable type.

THE net result of the combined experience and skill of all those participating in this program of research and development has been a tremendously expanded and accelerated supply of weapons of the highest fighting efficiency, accompanied by a saving of great amounts of critical materials and of millions of machine hours. This has been accomplished through the utilization of more plentiful materials and the simplification and standardization of processes and techniques. Several points about such an effective system for the development and production of superior military weapons merit emphasis.

First, as a result of years of experience in working together, the members of the existing agencies and facilities previously described know well their own functions and the functions and personnel of the other agencies and facilities with which they work. Such knowledge makes possible the close and intimate coördination and liaison, so essential in scientific and technical work, which have now been achieved and which are responsible so largely for the brilliant accomplishments in producing superior military armament. In such a system, confusion, gaps, and conflicts of interest are easily avoided. Yet specialization, which is so essential and so highly productive in research, is permitted to flourish. Each agency or facility works freely in its specialized field but in close coöperation with the Ordnance Department and other agencies and facilities. Thus, the Ordnance Department has the willing and complete coördinated coöperation of civilian engineers and scientists throughout the country.

Secondly, research works together as a team with production, inspection, and maintenance. All these operations are inextricably interwoven and require the closest type of coordination for the intensive effort which must be made to obtain superior weapons for the battle fronts. Consequently, the Ordnance Department is responsible not only for research and development, but also for production, procurement, storage, issue, and maintenance.

FINALLY, this research is directed by men trained in Ordnance with a background involving the use of weapons by troops. The Ordnance Department is dealing with matériel designed to accomplish certain military objectives on the battlefield. Tactics and strategy must conform to the potentialities of the available weapons. To design, develop, and engineer military weapons, therefore, the viewpoint of the soldier familiar with actual battle conditions and with the demands of military strategy and tactics is essential. The development of military armament and equipment is inseparably fused with military training, combat experience, and continuous and innumerable adjustments and changes in strategy and tactics.

Moreover, only those at the battle fronts with intimate daily and continuous contacts with the soldiers using those weapons in battle can discover and interpret the needs of those soldiers and transform such needs into suitable weapons. It is a soldier who fires the gun and it is this soldier whose life depends on the performance of the gun. His demands, therefore, must be discovered and given primary consideration in the development of the gun. The immediacy and intimacy of this relationship between military experience in training and combat and the timely supply of effective weapons to soldiers in battle is fully recognized by the present organization.

Therefore, the designers of our military weapons are men who can and do go to the theaters of battle, watch with trained eyes and analyze the performance of our weapons, ascertain from intimate contacts the needs of the troops, and then return to our laboratories and factories and transform their skilled observations into new and superior weapons. In fact, both the chief and the assistant chief of the Technical Division have made extended trips to the North African fronts, as well as to England, and officers from each of the development branches of the Technical Division have been overseas in order to make comprehensive investigations in their respective fields. The chief of the Tank and Motor Transport Development Branch came to this post after an extended tour of duty with British forces in Africa.

Such trips to the combat areas by Technical Division officers for observation, valuable as they are, only supplement the steady stream of important data on the performance of ordnance equipment and requirements for improvements

and new weapons which come from the Ordnance personnel regularly in the field with combat troops and at the various theater headquarters. These Ordnance representatives on the battle fronts are the "eyes" who see and accurately evaluate the needs which must be met. Their reports and messages serve as valuable guides for research and development in the continuous effort being made by the Ordnance Department to provide new and improved matériel for our combat forces and to meet the special demands arising in North Africa, Attu, the Southwest Pacific, and wherever our troops are fighting. Interchanges of such personnel with Technical Division and other Ordnance Department personnel are made in order to coördinate viewpoints and to insure that development is in accord with the realities of battle.

THE march of Ordnance development during the last few years has gone forward with gigantic strides. All are now familiar with the historic improvement in the Infantry shoulder weapon which resulted from the adoption of the Garand M1 semiautomatic rifle. The performance of this rifle was so remarkable in the Philippines that General MacArthur personally radioed Washington a commendatory report on it. When an urgent need arose early in the war for a new lightweight weapon for the individual soldier which would replace the pistol and would hit hard and accurately at distances of a few hundred yards, the caliber .30 carbine, M1, was designed, developed, engineered, and put into mass production in an amazingly short period of time by a private facility as a member of the Ordnance-industry-science partnership. This weapon has proved valuable where light weight, power, and accuracy at short ranges are demanded.

Similarly, when the need arose for a new submachine gun of improved performance which would require neither the raw materials nor machine tools demanded for the production of existing models of submachine guns in adequate numbers, the M3 submachine gun, fabricated mainly from stamped parts and therefore capable of being made by facilities not otherwise engaged or needed in war manufacture, was developed, engineered, and placed in production (see the September-October 1943 issue of ARMY ORDNANCE, Vol. XXV, No. 140, p. 349). This gun is the most rugged and accurate submachine gun known; in addition, it weighs several pounds less than, and costs about half as much as, standard guns of this type. Although in outward appearance a complete break with tradition, the M3 submachine gun embodies in its construction all the sound principles of gun design established as a result of years of study by the Ordnance Department and also all the production techniques developed by industry in this war.

The "Bazooka" made its debut in North Africa where it was successfully used by our forces to destroy both tanks and fortifications. This simple weapon carried in the hands of a soldier is so powerful that any one using it can stand his ground with the certain knowledge that he is master of any tank which dares to attack him. The "Bazooka" fires a projectile which will penetrate steel armor and drive through thick walls and masonry with a powerful destructive effect.

The General Sherman M4 medium tank has been so effective that in the words of the Under Secretary of War, "Rommel's troops never knew what hit them when they encountered the General Sherman tanks at the Battle of El Alamein." This tank, in fact, has been called by British officers and ranking captured German officers the best tank in the desert.

Our tank destroyers, such as the M10 with the 3-inch high-velocity antitank gun, and our self-propelled artillery, such as the M7 with the 105-mm. howitzer, have won high praise for outstanding performance under fire. The mobility and firepower of such weapons was one of the decisive factors in the Battle of El Alamein.

In fact, the tremendous firepower of all our artillery—such weapons as the 105-mm. howitzer, the 155-mm. howitzer, and the 155-mm. "Long Tom" field gun—have given our troops crushing superiority over the enemy on the fighting fronts. The performance of our artillery during the Tunisian campaign was a major contribution to the final triumph. In the words of one correspondent, "Our superiority in matériel, particularly our overweight in artillery, was probably the greatest single factor in victory."

Our antiaircraft weapons have demonstrated amazing accuracy, range, and power. The 90-mm. antiaircraft gun has repeatedly shown its utility and superiority. Multiple-gun motor carriages have proved extremely effective for antiaircraft defense. One such carriage, mounting two caliber .50 machine guns and a 37-mm. cannon, brought down nine enemy aircraft over Algiers.

Another important field of Ordnance development is aircraft armament. The caliber .50 machine gun was developed by the Ordnance Department at the close of the first World War and greatly improved during the years prior to this war. Today this machine gun is giving such planes as our Flying Fortresses the devastating firepower which has overwhelmed enemy air forces. Our 20-mm. and 37-mm. aircraft cannons have also performed brilliantly in combat. The precision and effectiveness of our bombing missions are a tribute not only to our superb planes and flying personnel but also to the reliable functioning and tremendous potency of the bombs, fuzes, and explosives developed and produced by the Ordnance Department. Ordnance is thus putting the punch into air power.

ORDNANCE development, therefore, is ever on the march—a march during which, in the present war, it has already recorded an amazing number of achievements. The bases for such achievements are laid long before the weapons themselves overwhelm the enemy on the battlefields. Prior to the use of this matériel in combat, the Ordnance Department has been engaged for many months in the arduous and exacting task of creating and producing it. In laboratories, factories, and research centers, and on proving grounds and battlefields, Ordnance is constantly fighting and winning a crucial battle—the struggle for decisive superiority in the design, development, and production of new and improved materials and weapons in order to conquer our enemies speedily and overwhelmingly and with a minimum of allied casualties.

Our armament development, therefore, must be and is always on the offensive. In this battle of research and production the brilliant creative imagination of the Ordnance Department, of our armed forces, of industry, and of science is pitted against our enemies and is constantly outguessing, outmaneuvering, and outperforming them.

The Ordnance Department is one member of a great American team, a team composed of all our armed forces, of industry, and of science. Ordnance is confident that, in partnership with industry and science, it will continue to supply to our armed forces and our allies countless new weapons of overwhelming firepower.

Ordnance for the Infantry

THE invasion of Sicily and the storming of the Italian mainland at Salerno have once again established the Infantry in her rightful place as Queen of Battles. Despite the spectacular achievements of our Air Forces and the splendid work of our tanks, tank destroyers, and mobile artillery, the Ordnance Department of the U. S. Army has never forgotten for a moment the essential rôle of the infantryman in battle and has provided him with superior weapons in sufficient quantities to meet the enemy in close combat on any front.

The sharpened blade has been an effective weapon for centuries, and the bayonet and trench knife are still in use today. Ordnance recently has perfected a 10-inch bayonet to replace the less wieldy 16-inch one, and the new 6¾-inch-blade trench knife, M3, is now being issued in quantity. The caliber .45 automatic pistol is still carried by certain classes of troops, but the sidearm has been replaced in most instances by the caliber .30 M1 semiautomatic carbine which has an accurate range of 300 yards, is 35 inches long, weighs less than 5 pounds, and carries 15 rounds in its box magazine.

The standard shoulder arm of the Infantry is, of course, the Garand semiautomatic rifle, caliber .30, M1. It has a much greater rate of aimed fire than the 1903 Springfield which it replaces.

Grenades are among the soldier's most effective weapons, especially for blasting enemy machine-gun nests or dugouts, and in jungle warfare. Grenades are of both offensive and defensive types, and some contain smoke or gas. A grenade launcher, attached to the infantry rifle, enables a heavy grenade to be projected accurately over a considerable distance.

The Ordnance Department has provided the infantryman with a variety of machine weapons. The Browning automatic rifle, Thompson submachine gun, and the new M3 submachine gun can accompany him anywhere. Heavier machine guns are the backbone of infantry power and our caliber .30 and caliber .50 weapons—both air- and water-cooled—are capable of a huge volume of sustained fire.

The development of the tank after World War I bade fair to drive the infantryman from the battlefield. But Ordnance has now produced for the foot soldier weapons which enable him to meet an armored attack on even terms. The "Bazooka" can easily be carried by one man yet it fires a rocket projectile capable of disabling any enemy tank (see illustrations on p. 566). The 37-mm. antitank gun is effective at longer ranges and may also be used to fire canister against personnel. The newly adopted 57-mm. and the new 3-inch antitank guns are indeed masters of the battlefield.

Today, the Infantry is no longer dependent on heavy artillery support to help it forward in the attack. The 60- and 81-mm. mortars can accompany the fighting troops almost up to the front line, and the 75-mm. and 105-mm. howitzers on light carriages can also follow close behind the troops. (Most of the accompanying illustrations are from photographs taken by the Signal Corps of the U. S. Army.)

The Infantry's Fast-Firing Rifles

The Garand semiautomatic rifle, caliber .30, M1, shown above, is now the standard Infantry shoulder arm. With it, the rifleman can fire a clip of 8 shots without taking his finger from the trigger. The Browning automatic rifle, below, weighs about 22 pounds and fires 20 rounds from its box magazine at an adjustable rate of from 300 to 600 rounds a minute.

Grenades Aid the Attack

The infantryman above is about to fire a rifle grenade from a grenade launcher which is attached to a Springfield rifle. This grenade may be fired accurately to a much greater distance than the hand-thrown grenade shown below. The latter type is used in close combat against enemy pillboxes, dugouts, and other strong points and is effective in jungle warfare.

The Machine Gun Is the Backbone of Infantry Power

The air-cooled caliber .30 machine gun, above, weighs only 31 pounds and may be easily transported by two men. It fires belt ammunition and has a cyclic rate of about 450 rounds a minute. The air-cooled heavy-barreled caliber .50 machine gun, below, weighs 84 pounds and has a rate of about 450 rounds a minute. It fires ball or armor-piercing ammunition.

The Infantry's Light Machine Weapons Are Versatile

Today's fast-moving mobile warfare and close-in jungle combat have brought the submachine gun to the fore as a most effective weapon on both attack and defense. The Thompson submachine gun, two of which are shown above, weighs nearly 11 pounds and carries 50 rounds in its drum magazine. The water-cooled caliber .30 machine gun is shown below.

Artillery for the Infantry

The 37-mm. antitank gun, above, helps protect the infantryman against armored attack. It has a maximum range of 5,000 yards and fires a projectile weighing almost 2 pounds. The 57-mm. antitank gun now complements this weapon. The troops shown in the plane below are equipped with the M1 carbine and the 75-mm. howitzer on mountain carriage.

Tank and Antitank Elements

Light tanks, such as the M5 light tank shown above, often accompany the infantrymen forward and help to neutralize strong points of enemy resistance with their 37-mm. cannon and machine guns. The new high-velocity 3-inch antitank gun, shown below, is able to stop any enemy armored vehicle that may threaten the infantry attack. It is easily camouflaged.

Infantry Mortars

Mortars are the Infantry's most versatile and effective weapons. The 81-mm. mortar, above, weighs 136 pounds and fires shells weighing from about 7 to 15 pounds over a range of from 100 to approximately 3,000 yards. The 60-mm. mortar, below, weighs 42 pounds and fires a 3-pound shell from 100 to nearly 2,000 yards at a normal rate of 18 a minute.

Erie Proving Ground

The Nation's Largest Establishment for Proof Testing Artillery

Col. Francis E. Rundell

ALONG the shores of Lake Erie at Lacarne, Ohio—thirty-two miles east of Toledo—lies Erie Proving Ground, an Ordnance establishment where the majority of the Nation's production of artillery and armor plate is proof tested before being shipped to our armed forces and our allies. Established on March 15, 1918, as one of the first proof-firing layouts of its type, the proving ground is celebrating its twenty-fifth anniversary this year by proofing more artillery and armor than ever before in its history.

Erie is essentially a "production-line" proving ground, and its object is to get matériel from the manufacturing facilities as quickly as possible, proof test it, and ship it off to the fighting fronts in a continuous and never-halting stream. On an average day, 50 railroad carloads and 70 truckloads of matériel—totaling $2,000,000 in value—are cleared through the establishment. During the average month, approximately 125,000 rounds of ammunition are expended in proof testing about 10,000 units.

In contrast, the Ordnance Department's huge establishment at Aberdeen Proving Ground, Md., while it proof fires much artillery for actual use, is primarily a research and development center where new ideas in ordnance and ballistics are worked out and tested and enemy matériel is examined for weaknesses and adaptable innovations. At Aberdeen, too, tanks and other combat vehicles are tested and all types of weapons perfected to the point where they are ready for mass production.

Not least among the achievements of Erie Proving Ground in World War II is the speed and efficiency with which it undertook and accomplished the gigantic expansion needed to keep pace with the similar increase in artillery manufacture. Two years ago the personnel of the proving ground numbered forty persons. Today there are approximately 3,000 civilian employees and about 100 officers and men of the Ordnance Department at Erie. Some commercial industries have expanded as much as 800 to 3,000 per cent in 20 to 40 years—Erie Proving Ground expanded 10,000 per cent in 2 years!

But Erie has a long record of Ordnance achievement, and such results were not surprising to those familiar with its past history. The entry of the United States into World War I on April 6, 1917, necessitated the establishment of increased facilities for the acceptance testing of artillery, and steps were taken to secure additional locations for this work. The site now known as the Erie Proving Ground was selected for one of these facilities, and land amounting to approximately two square miles, with one mile of shore, was purchased. This proving ground was established March 15, 1918, and was first designated as the Camp Perry Proving Ground, but, due to the confusion that arose because of its close proximity to Camp Perry, the designation was changed to Erie Proving Ground on August 31, 1918.

Construction work was started in May 1918, and in October of that year the plant was available for operation on a limited scale. The first troops arrived June 14, 1918, and consisted of 101 men of the 41st Provisional Ordnance Battalion; the military personnel reached a maximum of 450 enlisted men during the first part of 1919. The 84th Ordnance Company (Depot) was organized March 23, 1921, and was assigned to this proving ground until December 1941, at which time it was transferred to another station. During the period October 23, 1918, to March 20, 1920, 7,694 units of artillery matériel were proof fired.

AFTER the Armistice had been signed and all matériel that had been manufactured had been proof fired, the need of the establishment for acceptance testing no longer existed. Accordingly, it was transformed into an Ordnance depot and assumed its duties as a stores and issue point for artillery matériel. About this time the name, Erie Proving Ground, was changed to Erie Ordnance Depot. This was changed once again to Erie Proving Ground on January 11, 1941.

Early in 1940, plans were formulated by the Chief of Ordnance to activate the establishment for assembly and acceptance testing of the vast amount of artillery matériel which was to be manufactured. Additional permanent-type buildings, shops, proof facilities, roads, and utilities were placed under construction immediately. The largest of these is Building 160, which covers 16 acres of ground and through which runs a 2-track railroad spur.

The Industrial Service Division of the Ordnance Department reëstablished and expanded the proving ground for the purpose of assembly and acceptance testing. At the same time, the Field Service Division also expanded and has operated the Erie Ordnance Depot within the proving ground. The rapid expansion of the old Erie Proving Ground and Erie Ordnance Depot has made it possible to accept and maintain heavy programs scheduled by the Chief of Ordnance for processing, assembling, proof firing, receiving, and shipping artillery matériel. Today, Erie is the Nation's largest artillery proving ground. Approximately thirty-six per cent of the work at Erie, formerly handled solely by men, is now being ably handled by women. Three shifts of workers, commuting daily from towns all over northern Ohio, are employed.

The first cannon tested and proof fired at Erie during this war period was an 81-mm. mortar, manufactured by the Pullman-Standard Car Manufacturing Company and tested on May 21, 1941.

In consideration of the large amount of matériel received, inspected, and processed before and after proof firing and the prompt shipment of this matériel by the proving ground, the Army and Navy conferred the Army-Navy Production Award for excellence in appropriate ceremonies on October 1, 1942. The white star for continued excellence was awarded on August 21, 1943.

As a preliminary to the activities along the firing line, the shops of the proving ground assemble, clean, inspect, and generally prepare all incoming matériel for test. Proof acceptance testing involves a procedure intended to submit all

Colonel Rundell is the Commanding Officer of Erie Proving Ground, Lacarne, Ohio.

units and components of the matériel under test to stresses in excess of what will ever be encountered in field use. High-pressure rounds are fired at maximum traverse and elevation, and a number of standard or service rounds are fired to obtain information and data on possible deviations from specifications or evidences of malfunctioning. Close examination and inspection accompany all phases of proof procedure. Corrective action is completed and the matériel is shipped out ready for combat service.

FOLLOWING is a brief description of some of the artillery pieces under test at Erie Proving Ground:

240-mm. Howitzer.—This weapon is the largest mobile field piece used by the U. S. Army. The carriage is of the split-trail type and is transported on a pneumatically tired trailer. The cannon and other mechanisms are transported on a second trailer. The gun in firing position weighs about thirty-two tons. Each battery of 240-mm. howitzers utilizes a 20-ton truck-mounted crane. The gun is a long-barreled highly mobile unit weighing about twelve tons. The 240 is valuable as a means of heavy bombardment against fixed enemy positions and fortifications. It can be emplaced in about two hours and hurls a 360-pound projectile from seven to fourteen miles at a rate of about one round a minute.

155-mm. Gun.—The 155 is a long-range bombardment and siege gun whose employment is controlled by the army commander. The complete gun weighs about fifteen tons and is a mobile unit which hurls a 95-pound projectile about fifteen miles. It can be emplaced in thirty minutes and disemplaced in ten minutes, if necessary. It fires about three rounds a minute.

4.5-inch Gun.—In its use to fill the gap between the 105-mm. divisional artillery and the large army artillery, the 4.5 is a relatively new development. The gun is a long-barreled highly mobile unit mounted on a 2-wheel, split-trail carriage and weighs about six tons. It fires a 55-pound projectile over a range of about twelve miles.

105-mm. Howitzer.—This weapon was developed to replace the 75-mm. gun of World War I fame and to provide greater firepower and range for divisional field artillery. The unit weighs slightly more than two tons and is capable of hurling a 33-pound projectile approximately seven miles. The 105 is the "work-horse of the Army," being used as a bombardment and antitank weapon as well as being mounted on self-propelled mounts for "hit-and-run" tactics.

3-inch Antitank Gun.—This gun has become a standard weapon of the antitank battalion and is primarily intended for use against enemy armored vehicles. However, it also serves quite ably as a weapon for long-range shelling.

40-mm. Antiaircraft Gun.—The 40-mm. gun is of Swedish origin and with modifications is in use by the major powers on both sides in the present conflict. The 40-mm. is mounted on four wheels and is spring-balanced to permit the gun to be placed in firing position with a minimum amount of effort. The gun is used against both air and ground targets and has an approximate range of 7,500 feet. Fixed ammunition is fed into the gun in clips containing four rounds each. The 40-mm. is an automatic weapon operated either manually or by remote control. Eight guns constitute the normal battery, and each gun has its own director and generator.

90-mm. Antiaircraft Gun.—The 90 is mounted on a single-axle dual-wheel carriage and is a highly mobile, high-velocity weapon for use against ground and aërial targets. Fixed ammunition is loaded individually, and the gun is directed at its targets either manually or by remote control.

57-mm. Antitank Gun.—The so-called "6-pounder" is of British design, although American modifications have been made. The 57 is a high-velocity antitank weapon mounted on a 2-wheel, split-trail carriage. Its value against armored vehicles was proved in many encounters in the desert fighting in North Africa. This gun has an automatic breechblock which remains open after the cartridge case has been ejected and which closes and locks when a new round is rammed home. Consequently, a high rate of fire can be maintained with this weapon.

37-mm. Antitank Gun.—Proved effectiveness against enemy tanks and armored vehicles has caused the 37-mm. to become known as "Little Poison." This gun has a maximum range of about 5,000 yards and fires a projectile weighing almost 2 pounds.

37-mm. Aircraft Cannon.—This 37-mm. is an automatic cannon for mounting through the propeller hub of P-39 pursuit airplanes and other allied aircraft.

20-mm. Aircraft Cannon Feed Mechanisms.—The feed mechanisms for 20-mm. cannon are mounted in the wings or nose of combat planes and provide an ammunition supply for the over 500-round-a-minute rate of fire. These mechanisms are spring-operated and feed a fixed round of ammunition having a projectile weighing about four ounces.

3-inch and 75-mm. Tank Guns.—The 3-inch tank gun used in the turret of the new M10 tank destroyer is an adaptation of the 3-inch antiaircraft gun for use as a tank gun. The M10 and its high-powered gun provided plenty of trouble for the Axis forces in North Africa. The 75-mm. tank gun provides the striking power for the potent General Sherman tanks which the Axis has learned to respect.

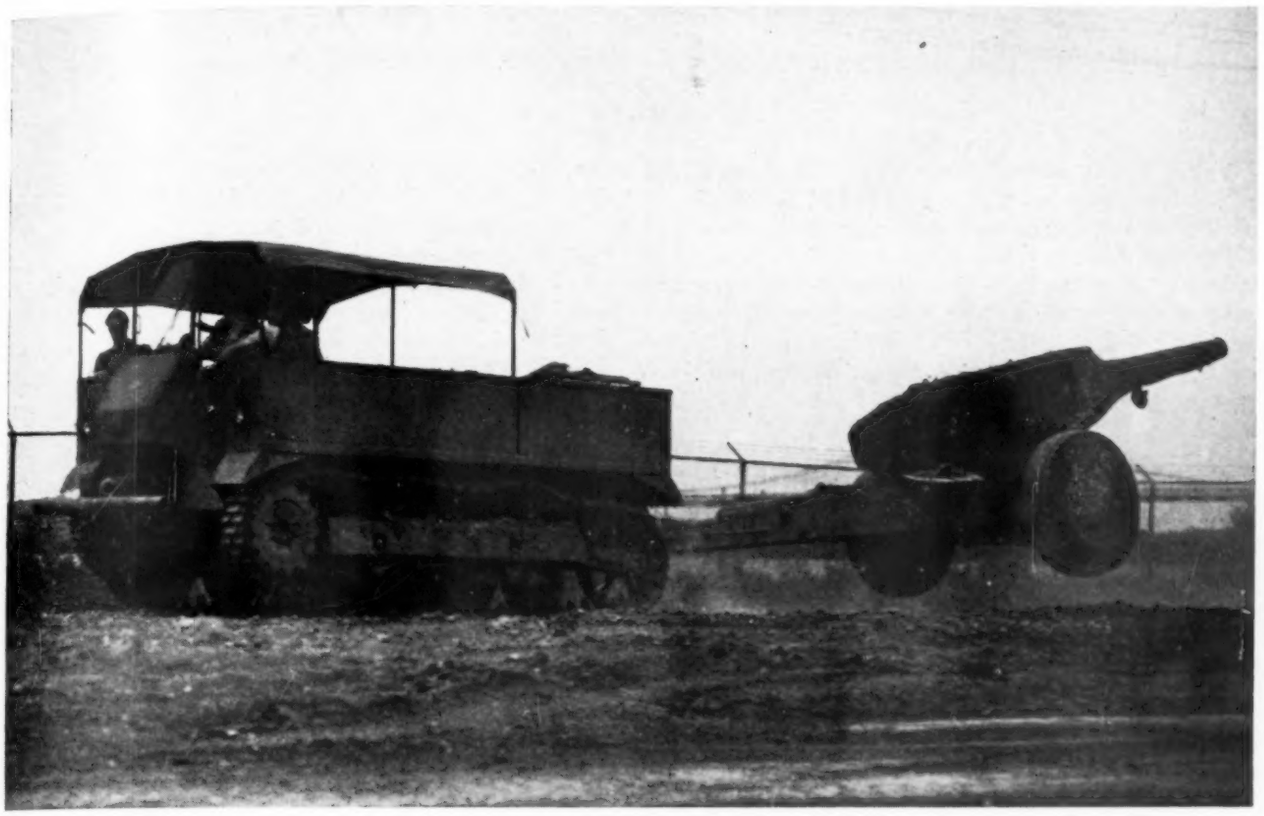
THE Erie Proving Ground is approaching at this time a new high in armor-plate testing activities. The facilities employed provide the largest and most modern plate-testing range in the country. At present the range is acceptance testing more armor than all other ranges and proving grounds combined—or approximately seventy per cent of all armor produced in the United States. The plate is made in furnaces throughout the northeastern and midwestern sections of the country and is not released for use on any Army equipment until exhaustive tests of each heat are made.

Two closed ranges over 300 feet long, constructed of 10-inch-thick reënforced concrete, and two outdoor ranges are in use. Caliber .30 and .50 machine guns, 20-mm. aircraft guns, and 37-mm. guns are used in the closed ranges, while 57-mm. and 75-mm. guns are tested outdoors.

The depot of Erie Proving Ground has managed the huge problem of shipping artillery to the armed forces overseas and within the United States. In performing this mission, new and approved methods of packing and crating for overseas shipment have been developed and established as standard by the Ordnance Department. The depot has loaded the rails and roads from Erie Proving Ground with more matériel than in any other one location in the United States.

Thus, today, Erie Proving Ground celebrates its twenty-fifth anniversary with a proud record of a quarter of a century of distinguished Ordnance service behind it, and its personnel are happy in the knowledge that whenever an artillery weapon fires against the enemy on our far-flung battle fronts or whenever American armor turns hostile steel it is very probable that Erie Proving Ground first made sure of the firepower and dependability of this matériel.

New Army Vehicles



Above is the Army's new high-speed tractor, M5, which is used as a prime mover for the 105- and 155-mm. howitzers and the 4.5-inch gun. It is shown towing the new 155-mm. 7½-ton howitzer at about 30 miles an hour. Below is the Army's new 40-ton armored tank-recovery unit, M25, shown loading a 30-ton M4 tank at the Washington Back the Attack display.

Convertible Small Arms

The Evolution of Hand Weapons for Semi- and Full-Automatic Fire

V. Alexander Scher

RECENT dispatches from the Russian front tell of Russian parachutists who drop behind the lines in the zone of German occupation and arm guerrillas operating in the rear of the enemy with weapons particularly suited to their tasks. These weapons are described as light, small, and easily concealed firearms which may be conveniently used for single-shot firing by snipers attacking sentries and individual soldiers or instantaneously converted into machine guns emitting a stream of bullets and adapted for use in mass fighting.

Present-day improvements in the construction of such convertible firearms must necessarily remain a military secret until the termination of the war. However, there is sufficient literature available to the general public, particularly in the form of patents granted and published before the war by our Patent Office, to describe the precursors of weapons now wielded with such deadly accuracy by our allies and make it possible for us to learn the basic principles of their structure.

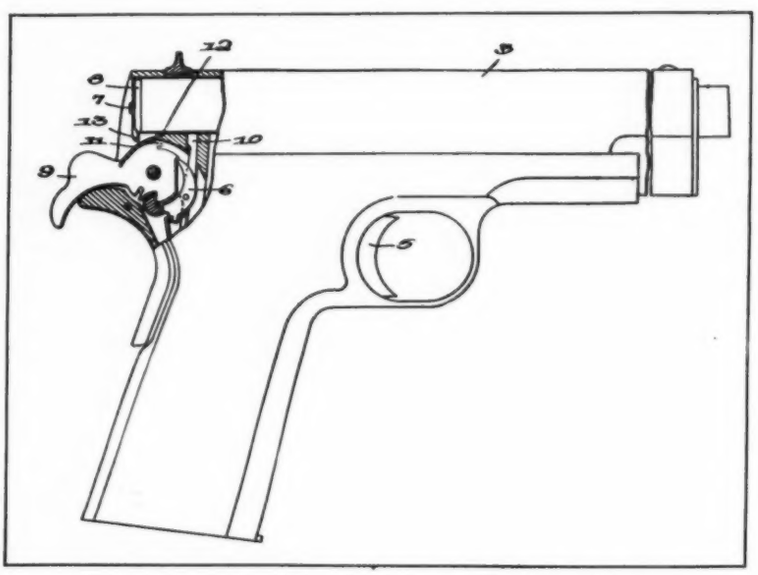


Fig. 1. Hayslip's Conversion of the Browning Pistol

At the turn of the century, the basic structural principles of our pistols and revolvers were already evolved. Since the magazines and cylinders of these weapons contained only seven or eight cartridges, continuous automatic firing would have been a drawback instead of an advantage, for the weapon would have been completely unloaded in a second or two. Therefore, most of the inventors at that time tried to improve the safety of the weapons and to prevent any possibility of an accidental discharge of a second shot after the first shot was fired.

Nevertheless, the success and rapid development of the machine gun became a continuous incentive to a few inventors who planned to provide a machine gun of pocket size. They were not deterred by the fact that at that time the science of warfare was developing in an entirely different direction; namely, toward bigger armies and heavier guns. They produced weapons which brought them little financial return during the lifetime of their patents, but their principles were utilized by others decades later.

A continuously firing small arm became a practical possibility with the invention of a secondary magazine which could be attached to a pistol to increase its supply of cartridges from seven or eight to thirty or forty. These detachable magazines, which became the subject of a large number of patents, increased the duration of continuous firing and brought it within a usable range.

One of the earlier convertible pistols was invented by Elbert H. Searle of Philadelphia and is described by him in his United States Patent No. 804,984, issued November 21, 1905. The inventor contemplated the use of his weapon by cavalrymen during an attack. The rider was instructed to hold the bridle with one hand and spray the enemy with bullets by means of the pistol held in the other. Searle's pistol has a small hammer which is enclosed in the case and cocked by the recoil movement of the receiver. The hammer is engaged by a bifurcated sear of irregular shape. Connection between the trigger and the sear is established by an elongated rod, one end of which is pressed against the trigger while its other end has a projection which engages an arm of the sear. When the trigger is pulled, the rod is also actuated, and it releases the sear from its locking engagement with the hammer so that a spring can swing the hammer and cause it to hit the firing pin. The receiver has a projection which lifts the rod out of engagement with the sear after a shot has been fired during semiautomatic firing, thus making it possible for the sear to reëngage the hammer and hold it in the cocked position at the end of the recoil, even though the user continues to press against the trigger.

In order to set the pistol for automatic action, the patentee provides a tripping fly which may be set by the movement of the thumb of the hand holding the pistol. In its operative position, the tripping fly is interposed between the rod and the sear, and it automatically releases the hammer from its engagement with the sear each time the receiver returns to its firing position. This pistol, the magazine of which is constructed to contain a double amount of cartridges, is one of the earliest small arms capable of machine-gun action. While the parts of the pistol may be assembled without the use of screws, they are complicated and expensive and are quite heavy in weight.

Charles F. Lefever, of Toledo, Ohio, utilized a somewhat similar method in order to convert a revolver into a continuously firing weapon. This revolver is described in his

Mr. Scher is a member of the firm of Richards and Geier, patent attorneys, New York City.

U. S. Patent No. 944,448 of December 28, 1909, and is of the type wherein the recoil of the breech piece is utilized to recock the hammer and turn stepwise the cartridge-carrying cylinder. Lefever uses a sear with a very long nose which is located close to the rear end of an elongated lever. The front end of the lever has the form of an upturned hook. During the usual semiautomatic firing the hook is situated below the breech piece. In order to set the revolver for continuous firing, the user presses a button with his thumb which moves an end of a finger between the nose of the sear and the rear end of the lever. At the same time, the finger trips the lever sufficiently to place its hook-shaped front end into the path of the recoiling breech piece. Then the lever is swung by the breech piece during the recoil caused by the firing of the first shot so that the lever can push the finger against the sear, thereby withdrawing the sear from engagement with the hammer and permitting the hammer to fire the next shot automatically.

A PISTOL of the old Luger type was converted into a continuously firing weapon by two Mexicans—Manuel and Everardo Navarro of the city of Celaya in the state of Guanajuato, Mexico. Their invention is described in U. S. Patent No. 1,113,239 of October 13, 1914. It is well known that the old Luger pistol has a breechblock which is moved backward by the recoil and which is pivotally connected with toggle levers provided with rollers. During the recoil movement, these rollers travel up and down on cam faces forming a part of the framework. The pistol is fired by pulling a trigger which is connected to a locking and releasing lever engaging a lug constituting a part of the firing pin. When the trigger is pulled, the locking and releasing lever releases the lug and the firing pin can then strike the cartridge. During the recoil, the roller carried by the toggle lever reëstablishes the engagement between the locking and releasing lever and the lug of the firing pin. The locking and releasing lever is normally held against outward movement by a free end of another spring-pressed locking lever which is located in the handle of the pistol close to its back surface.

The invention of the Navarro brothers consists of a spring plate which is mounted upon the locking and releasing lever and which may be shifted to a forward or rearward position. In the forward position the spring plate is inactive, and the pistol is operated in the usual manner. However, by loosening a hand-operated screw, the user may shift the spring plate to the rear position in which it is situated within the path of movement of one of the rollers carried by the toggle levers. During the recoil, this roller strikes the spring plate and the latter swings the locking and releasing lever, thereby automatically releasing the lug of the firing pin and producing the next shot. It is apparent that firing will continue automatically provided that the hand of the user continues to press against the spring-engaged locking lever situated in the handle of the pistol.

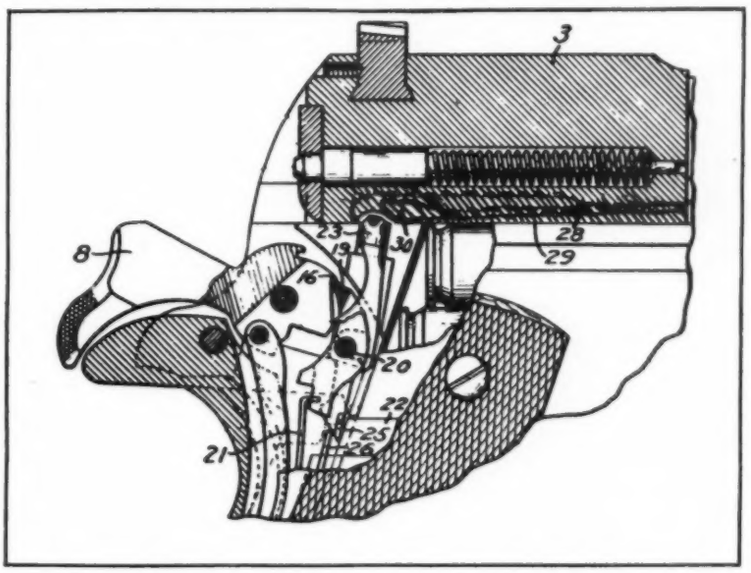


FIG. 2. CONVERTED MECHANISM OF THE COLT ARMY PISTOL

A PISTOL of simple and yet effective construction which may be conveniently used for single-shot as well as for continuous firing was invented by Grant Hammond of New Haven, Conn. This pistol is described in his U. S. Patent No. 1,410,248 of March 21, 1922.

An important feature of this pistol is the provision of a controller which is mounted in the frame and which may be turned by hand into one of three positions. The controller is located within the recess of an actuating bar, one end of which is engaged by the trigger. The other end of the actuating bar has a notch receiving one end of a sear-actuating finger which is firmly connected with a hammer-engaging sear through the medium of a sear shaft. One of the three positions of the controller is a locking position in which the actuating bar is held so firmly by the controller that pressure upon the trigger is not transmitted to the actuating bar. In this locking position the pistol cannot be fired.

The second position of the controller, in which only single shots can be fired, is one in which the controller is so turned that it is entirely out of the way of the actuating bar. Then, if the user pulls the trigger, the actuating bar will swing the sear-actuating finger, and the latter, through the sear shaft, will withdraw the sear from engagement with the hammer. Then the hammer will swing forward under the action of a spring, strike the firing pin, and fire a shot. During the recoil, the receiver will press downward an actuator, which will disengage the actuating bar from the sear-actuating finger, thus making it possible for the sear to engage the hammer again after it is cocked by the recoil action of the receiver.

In the third position of the controller, firing takes place continuously as long as the trigger is held back and there is a supply of cartridges in the magazine. In this position, the controller allows the actuating bar to be moved by the trigger, but it maintains the actuating bar in continuous engagement with the sear-actuating finger and prevents a disengagement of the bar from the finger by the actuator. In that position the sear is prevented from reëngaging the hammer after the recoil caused by the firing of the first shot.

This construction alone, however, would not result in continuous firing, since the hammer would swing close to the firing pin and would not strike the pin with the required force after the first shot. In order to maintain the hammer automatically at a distance from the firing pin for the required time period and then to release it to produce

the next shot, the inventor uses a second sear, which he calls a "safety sear" and which is automatically operated by the recoil of the breech bolt to release the hammer after it has been held in the cocked position by the safety sear for a predetermined time period.

William F. Kellotat of Portland, Oreg., converted the old semiautomatic Browning into a weapon which continues to shoot automatically like a machine gun while the trigger is depressed. This pistol is described in U. S. Patent No. 1,924,159 of August 29, 1933, and is illustrated in Fig. 4. It comprises a spring-actuated swingable hammer (9) which is held in the cocked position by a sear (10). The trigger (12) is connected with an elongated trigger bar (11) which is pressed upward by a spring (12*a*).

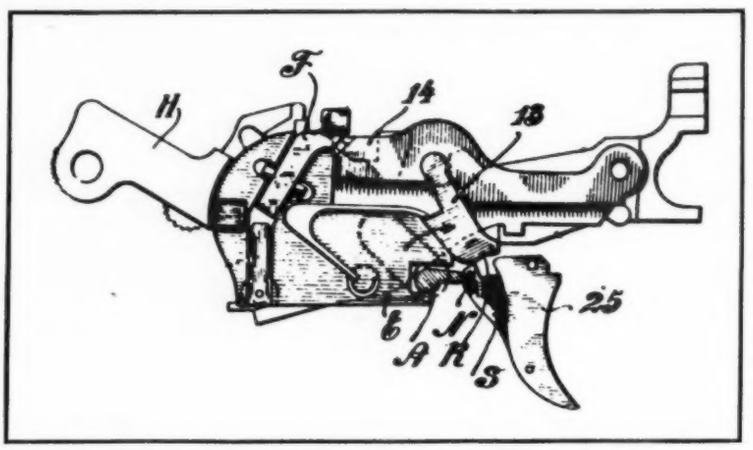


Fig. 3. Conversion Mechanism of the Mauser Pistol

When the user pulls the trigger, the trigger bar is moved forward, and its rear end slides in engagement with an underlying surface of a depressor finger (30), engages a beveled face (10*a*) of the sear, and rotates the sear forward. Then the sear releases the hammer which is swung by its spring against the firing pin (17) so that the first shot is fired. As the breechblock (7) carries out its recoil movement, its rear bevel (28) raises the rear end of the trigger bar while the hammer is recocked and is again engaged by the sear. Then the reaction spring (18) returns the breechblock to its initial position shown in Fig. 4, and close to the end of this movement the depressor finger presses downward upon the rear end of the trigger bar, causing the latter to move the sear forward, thereby automatically releasing the hammer for the next shot.

This pistol embodies a particularly simple conversion mechanism, since the only part changed in the old 1918 model is the trigger bar. However, the drawback of this construction is that the converted pistol can be used only for machine-gun firing, since no means are provided for changing it back to a single-shot weapon.

U. S. Patent No. 1,964,634 of June 26, 1934, to Estelle Hayslip of Bakersfield, Calif., describes a converted Browning pistol which is very simple in construction and effective in operation. As was the case with the Kellotat mechanism, Hayslip's conversion is carried out by means of a minimum number of parts. Fig. 1 illustrates a pistol having a hammer (9), a safety or disconnecter (10), and a sear (6) actuated by a trigger (5). The hammer differs from the hammer of the conventional Browning pistol in that a part of its striking face is filed off, and it is provided with a resilient strip (11) adapted to engage the portion (12) of the pistol frame. The safety of the conventional Browning pistol is made ineffective by filing off its upper end, and the stop (8) of the firing pin (7) is provided with a downward-extending lug (13). These are the only changes made by the inventor in the Browning pistol.

In order to fire the pistol for the first time, it is necessary to cock the hammer by hand and then pull the trigger. The sear is then withdrawn from engagement with the hammer, and the latter strikes the firing pin, firing the shot. During the recoil, the hammer is returned to its cocked position by the breech slide (3) and is retained for a while in that position by the engagement of the strip (11) with the abutment (12) of the pistol frame. During the return movement of the breech slide, the lug (13) pushes down the strip, thereby releasing the hammer and allowing it to strike the firing pin at a time when it is at a sufficient distance from the hammer. Thus, automatic firing will continue until the trigger is released or the supply of cartridges is exhausted.

This construction has the advantage that a conversion from a conventional Browning is accomplished with practically the smallest possible number of new parts and very few changes in existing parts. However, this construction has the same disadvantage as the Kellotat gun, namely, that the only way to convert it back to a semiautomatic is to remove the ineffective safety and replace it with the old full-size safety or disconnecter which can operate in the conventional manner and provide an engagement of the sear with the hammer after each shot.

The Germans have contributed to the development of automatic small arms an invention which is owned by the Mauser-Werke A. G. of Oberndorf in the Ruhr and which is described in U.S. Patent No. 1,980,874 of November 13, 1934. The German pistol is provided with an auxiliary magazine and is intended to carry about twenty cartridges. In comparison with American pistols, the mechanism is clumsy and complicated, the parts are heavier, and the danger of breakage is much greater. A part of the mechanism is illustrated in Fig. 3. The pistol carries a lever (E) which may be swung by hand to one of two positions; in one of these positions the pistol is used for single-shot firing while in the other it operates like a machine gun.

The position shown in the drawing is the machine-gun position, in which an arm (A) which is operated by the lever (E), is in engagement with a locking member (S) carried by the trigger (25) of the pistol. When the trigger is pulled, the engagement of the arm (A) with the locking member (S) will cause the projection (N) of the locking member to engage a recess (R) of a sear pawl (13). This connection between the trigger and the sear pawl will keep the sear (14) out of the path of the hammer (H) and will prevent the sear from reëngaging the hammer as long as the trigger is depressed. The hammer is maintained in a cocked position until the return of the breechblock by an auxiliary sear or safety (F). It is believed that this model was not particularly successful and that it was soon discarded by the Germans in favor of still heavier weapons of larger size.

During recent years several attempts were made to convert the famous Colt pistol of the United States Army into a continuously firing machine gun. A few parts of this pistol

are illustrated in Fig. 2. As is well known, the Colt pistol is provided with a disconnecter (23) which is mounted upon the same pin (20) as the sear (19). The top of the disconnecter fits into a notch on the lower side of the slide (3) when the slide is in its rearward position. A mainspring has arms (21) and (26) pressing against the sear and the disconnecter, respectively. When the trigger is pulled, the rear end (22) of the trigger slide will engage and swing the disconnecter. If the top of the disconnecter is in the notch of the slide (3) at that time, the lower part (25) of the disconnecter will engage the sear and will pull it out of engagement with the notch (16) of the hammer (8), thereby firing a shot. On the other hand, if the top of the disconnecter is pressed downward by the lower side of the slide, the lower part of the disconnecter will be located below the sear, so that if the trigger is pulled at that time, the disconnecter will not engage the sear, and no shot will be fired. If the shooter continues to press against the trigger, the rear end of the trigger slide (22) will maintain the disconnecter in an inoperative position after the first shot has been fired.

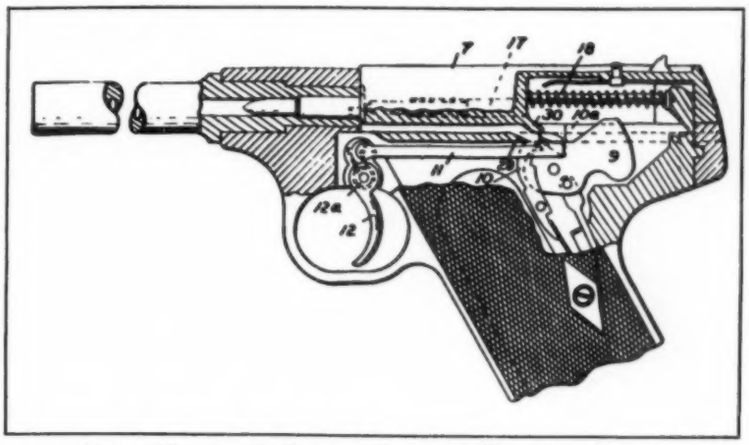


FIG. 4. KELLOTAT'S CONVERSION OF THE BROWNING PISTOL

CHARLES J. MICHAL, JR., of Hinsdale, Ill., who won U. S. Patents Nos. 2,056,975 and 2,139,691 for his invention, has added to this construction a cam (not shown) mounted on the receiver and having an end which is actuated by the slide. Another end of the cam carries a pin which engages the rear end of the trigger slide but does not touch the disconnecter.

This cam device makes it possible to fire the Colt continuously, one shot after the other, as long as the user continues to press his finger against the trigger. When the slide moves rearward after the firing of the first shot, it will swing the cam, and the pin carried by the cam will push the trigger slide forward and away from the disconnecter, despite the continuous pressure exerted upon the trigger by the finger of the shooter. Then the disconnecter will be freed and its top can move into the notch of the slide under the action of the mainspring. If the user continues to press against the trigger, the trigger slide will engage the disconnecter as soon as the cam is released by the slide. The disconnecter will withdraw the sear from engagement with the hammer, and the next shot will be fired. This simple device makes it unnecessary to release pressure against the trigger and then exert it again in order to fire a second shot. Its disadvantage lies in the fact that the finger must follow the trigger during the entire shooting. Furthermore, no means are provided for a quick conversion of the automatically firing Colt into a semiautomatic.

W. L. Swartz in U. S. Patent No. 2,169,083 of August 8, 1939, proposes a different conversion for the Colt pistol. According to his invention, the lower face of the slide is recessed to provide a groove (28) shown by broken lines in Fig. 2. A leaf spring (29) having a head (30) is situated in the groove and may be moved by hand from an upper position to a lower position and back to the upper position. In the lower position shown in Fig. 2, the spring (29) replaces the lower face of the slide and presses the disconnecter (23) downward after the first shot is fired, thereby preventing the firing of the second shot. However, the spring may be easily moved to an upper or retracted position, and then the top of the disconnecter will remain in the groove so that the lower part (25) of the disconnecter will remain in engagement with the sear (19), enabling continuous firing. The patentee also provides an automatic auxiliary sear which is operated by the slide.

This patent, which is owned by the Colt's Patent Fire Arms Manufacturing Company, is one of the last conversion patents issued prior to the outbreak of war in Europe. From that time on, the fog of secrecy descended, ever heavier and thicker, on inventions pertaining to firearms.

EDITOR'S NOTE.—Ralph Milne Farley writing on the Michal conversion in an article on "Weapons and the Law" in the September-October 1937 issue of ARMY ORDNANCE (Vol. XVIII, No. 104, p. 91) comments that the uniform anti-machine gun law adopted by a large number of states does not apply to the Michal-converted Colt because of its unique mechanism and because the law defines a machine gun as "a weapon of any description by whatever name known from which more than two shots or bullets may be discharged by a single function of the firing device."

Michal's conversion, Mr. Farley states, "is not like that sometimes obtained by gangsters who remove the disconnecter or file off its top end. For, as the Michal patent says: 'The use of my converter has quite a different result from what would obtain if the disconnecter were omitted, and the trigger slide were lengthened to bear directly against the sear. For, in that case, the sear would merely be held out of engagement with the notch on the hammer, and the hammer would return at counterrecoil, with a force which might or might not discharge the piece. Whereas, in my invention, the hammer is successively cocked and positively discharged. . . .'

"Note that this weapon," Mr. Farley continues, "which unquestionably *is* a machine gun, does *not* fire more than one shot with each 'single function of the firing device'—with each 'pull of the trigger.' The shooter's own finger unconsciously performs a function which normally would be performed by a part of the mechanism of a machine gun; namely, by a yielding spring between the trigger and the trigger bar. If the Michal gun had such a spring, which it does not, the trigger would be held down during automatic firing, the trigger bar would reciprocate against the spring, and the weapon would *then* fall within the definition of 'machine gun' in the uniform act."

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NOVEMBER-DECEMBER, 1943

Month by Month

War Production.—Donald M. Nelson, War Production Board chairman, speaking in London at a dinner given by the British Government in his honor, said that American war production this year would be at least 1½ times the combined output of Germany and Japan and next year probably would be twice as great. The United States alone, he said, produced 110,000 military planes since January 1, 1942, "and the production curve is still rising" so that very soon we will be turning out a completed plane every 5 minutes around the clock, every day of the month.

Since January 1, 1942, Mr. Nelson said America produced 60,000 tanks and tank chassis, 53,000 scout cars and carriers, and 1,100,000 trucks and trailers. More than 21,000,000 deadweight tons of merchant vessels and nearly 3,000,000 displacement tons of naval vessels have come from our shipyards during this time.

As for artillery and ammunition, he said enough had been manufactured "to let us fire nearly 2,000 shots at every soldier in the Axis armies."

During July, 7,373 planes were manufactured, a 4 per cent increase over the June level, including a 19 per cent increase for fighters and an 8 per cent increase for transports. Heavy bombers showed a gain of 13 per cent.

The Army announced that from January 1, 1942, to July 1, 1943, it accepted over 73,000 planes. U. S. plane production for the first 7 months of 1943 reached a rate of 7,000 a month, of which the Army has been getting 4,500. Some experts calculate that by the end of 1943 total plane production will not be far from the President's figure of 185,000. In the first 7 months of 1943, American shipyards turned out 1,046 vessels totaling 10,500,000 tons—the President's original figure for the entire year of 1943.

"Production and more production," must indeed be the watchword when it is realized that our armed forces suffered the following losses in matériel during the successful invasion of Sicily: We lost 13 per cent of all the 155-mm. howitzers landed, 46 per cent of all 57-mm. guns, 36 per cent of the motor carriages for our 75-mm. guns, 22 per cent of the carriages for our 105-mm. howitzers, and 54 per cent of the carriages for our 37-mm. guns. We also lost 7 per cent of our light tanks and 8 per cent of our medium tanks, and nearly 13 per cent of our 37-mm. guns.

TNT over Europe.—The production of military high explosives must also keep pace with the mass manufacture of weapons. This is particularly true with regard to explosives for our bombers, for more Ordnance bombs are now being dropped on Hitler's European fortress in one raid than were dropped during an entire month last spring. The ammunition record of the Eighth Air Force in Great Britain shows that 14 months ago, in August 1942, 340,000 pounds of bombs were dropped on Nazi installations. In December 1942, this total was more than doubled—762,000 pounds. In April 1943, the figure was 1,994,000 pounds. For the period June-July 4th, the Eighth Air Force called on Army Ordnance for 5,024,000 pounds of bombs. However, in one 45-minute raid on Hamburg, Flying Fortresses unloaded 5,152,000 pounds of high-explosive missiles. This amount of high explosives would make available a month's supply of coal in the United States; it represents approximately a year's supply of explosives used in blasting the route of the Panama Canal.

Skip Bombing.—The battle of the Bismarck Sea is a classic. The loss in *ships* by the Japanese in this battle was greater than the loss in *men* by the allied forces. The Japs lost 22 ships, 12 of them transports and 10 warships. Their loss in men possibly was 15,000 or more. It was an excellent example of successful teamwork between the Army Air Forces and the Ordnance Department. The "tools" were furnished by Ordnance; their highly successful use was a matter of flying skill.

The decks of the ships were first swept by caliber .50 machine-gun fire. The enemy's casualties were heavy, and his antiaircraft defense was held down so that our bombers could do their part. Every sort of bombing was used, but of particular interest here is the new type of fuze which permitted skip bombing and the highly successful use of this new technique by the Air Corps.

Every American boy has amused himself by skittering or skipping stones on the surface of water to see how many splashes he could get from a stone before it sank. It remained for Col. Sargent P. Huff, of the Ordnance Department, to direct the development of a fuze and a sight, and to accumulate the data necessary to make it practicable to skip a bomb against a ship with devastating results. The fuze has incorporated in it the necessary time delay to permit the plane to

drop a bomb from a very low altitude and get away from the danger zone created by the bomb blast.

Although the necessary development was done in this country, the new skip-bombing technique had not yet been proved in large-scale action against the enemy; hence the necessary fuzes were not available in quantity, and when the need for them arose in the South Pacific, the work of improvising manufacturing facilities there from simple field equipment fell upon Lieut. Col. John R. V. Dickson, also of the Ordnance Department. This work was completed only forty-eight hours before the Bismarck Sea engagement. When the approach of the enemy convoy was reported, he worked unceasingly to prepare the fuzes necessary for this action. The resulting annihilation of the Japanese fleet speaks for itself. Both Colonel Huff and Colonel Dickson have been awarded the Legion of Merit for their achievements.

Another skip-bombing raid on the Ploesti oil refineries in Rumania on August 1st destroyed forty-two per cent of their total capacity.

DIFFICULTIES in obtaining materials on time, manpower shortages both at our printer's and in the postal system, and difficulties of transportation may occasionally result in ARMY ORDNANCE *being delivered behind its regular schedule. We sincerely regret any inconvenience caused our readers by such delay, and we will do everything possible to insure on-time publication and prompt delivery of the magazine.*—EDITOR.

General Williams Retires.—Maj. Gen. C. C. Williams, who was Chief of Ordnance from July 1918 to April 1930, was relieved from active duty upon completion of the work of the War Department Procurement Review Board, of which he was a member, on August 31, 1943. General Williams was called from retirement to active duty on January 15, 1942. He was made a member of the National Defense Research Committee on March 31, 1942, and was also War Department liaison officer with that group after April 28, 1942. He was relieved of duty in connection with the Committee upon the formation of the War Department Review Board on July 7, 1943.

Following are excerpts from a letter by members of the Committee to Maj. Gen. Lucius D. Clay, Director of Matériel, Army Service Forces, expressing their appreciation of General Williams' services:

"The wise counsel and guidance of General Williams have been invaluable to the Committee and have contributed in great measure to the success it has achieved. To the frequent meetings of N.D.R.C. General Williams always brought carefully considered evaluations by competent military authorities of the various research and development proposals which were to be considered at the meeting. To assist him in securing these evaluations General Williams in his own office maintained a somewhat informal, but, nevertheless, highly effective coördinating agency for the research and development projects which were of joint interest to the Army and to the N.D.R.C. When, in the handling of projects or contracts or finances involved in this large program, there arose the inevitable problems of coördination or the resolution of various interests, General Williams showed great skill in smoothing the way for effective prosecution of the work.

"His wide experience and contacts, his sympathetic personality, his complete loyalty and integrity made him in his own person an invaluable member of the Committee. Although we know that in his long career as an officer General Williams has made many contributions of great importance to the United States, we feel that this last tour of duty of his was so significant that it must rank with the highest of his accomplishments."

ARMY ORDNANCE wishes to add its "well done" and best wishes to this tribute to one of America's outstanding Ordnance leaders and a member of the Army Ordnance Association since its foundation.

Rocket Weapons.—Current speculation on the practicability and effectiveness of rocket weapons and projectiles was given greater impetus and a stronger basis of fact by Prime Minister Churchill's recent remarks in his address before the House of Commons. After stating that German retaliation for allied successes must be expected, he said:

"The speeches of German leaders from Hitler downward contain mysterious allusions to new methods and new weapons which will presently be tried against us. It would be, of course, only natural for the enemy to spread such rumors in order to encourage his own people.

"There is probably more in it than that. We have, for example, now had experience on a new type of aërial bomb which the enemy has begun to use upon our shipping at close quarters on our ships close to the coast. This bomb may be described as a sort of rocket-assisted glider which releases its bombs from a height and is directed toward its target by a parent aircraft.

"It may be that the Germans are developing other weapons on novel lines with which they hope to do us damage. I can assure the House that unceasing vigilance and most intense study—the most intense we are capable of giving—is being given to these possibilities. So far we have always been able to find an answer to any new problems presented. At the same time no one must exclude from their minds that novel forms of attack will be employed."

Despite this somewhat startling disclosure, rocket weapons are not new in this war. For some time past, accounts from the Russian front have mentioned the rocket projectile carried beneath the wings of the Stormovik airplane and used with good effect against tanks and other armored vehicles, and news pictures have showed in some detail the German "6-barrel rocket gun," in appearance much like a multiple field howitzer. In our own Army, the "Bazooka"—new antitank weapon for the infantryman—has a projectile that operates on the rocket principle (see illustrations on p. 566). Obviously, the potentialities of rocket weapons are being explored by the armed forces of both allied and enemy powers, some successful results have been achieved, and further developments may be expected. If the enemy should develop an effective rocket weapon, we may be sure that, as always, the United Nations will "find an answer."

"Improvisation" versus Fact.—The ease with which military fables can grow is amusingly illustrated by a statement in the preface of the recent Modern Library edition of Von Clausewitz' "On War." The statement is there made that "We Americans have entered this war, as we have entered all wars, under the impulse of circumstances and we have improvised the weapons by which to wage it."

This statement gives scant credit to the work of the Ordnance Department through the years between World Wars I and II. That our depots had an insufficient stock of armament to arm our troops as they were called to the colors cannot be denied, but this is explained by the fact that through the years between the first and second World Wars scarcely three per cent of our national War Department budget was available for the activities of the Ordnance Department, the development of new weapons of war, and the accumulation of depot stocks.

It certainly is going far astray to state that our weapons of war have been "improvised" since Pearl Harbor. Development, rapid development, there certainly has been, and some improvisation may have been made necessary because of the shortage of depot stocks. But one has only to recall our Garand rifle, our tanks, our trench mortars, and our caliber .50 machine gun to show that Ordnance was not asleep during the interim of peace.

Another statement to which we take emphatic exception was recently given publicity. It was to the effect that our Mark IV tank closely follows the medium tank which the Canadians call the Ram. With all due credit to the Canadians for their splendid achievement, the fact is that the design of our Mark IV preceded that of the Ram.

Such careless statements are very unfortunate. They tend to create an entirely unwarranted lack of confidence in our material which is flatly contradicted by reports from all fighting fronts. The devil is entitled to his due!

Holabird Changes Hands.—For the second time since the beginning of the war, Holabird Ordnance Depot at Baltimore, Md., has changed hands. The depot has been redesignated the Holabird Signal Depot, and the Signal Corps will take formal possession on November 1st. Transfer of equipment and personnel is now under way.

Ordnance previously had transferred its motor-transport training to Aberdeen Proving Ground, and repair activities and preventive-maintenance functions are being distributed among various Ordnance installations. The new Signal Depot will store and issue air-borne and ground equipment and will take over the activities of the Monmouth Signal Depot, which will be discontinued.

Holabird is a Government-owned property within the city limits of Baltimore. It was originally designed as a Quartermaster depot with spacious warehouses, shops, a 200-bed hospital, housing facilities for more than 400 officers and 2,400 enlisted men, and a modern, fireproof office building.

Lend-Lease.—The President's quarterly report on Lend-Lease showed that materials and services for May, June, and July totaled $2,870,867 to make a grand total of $13,973,339,000 worth of Lend-Lease aid given since the law was enacted in March 1941. Great Britain received the largest amount of assistance under the program, but Russia, the second largest recipient, received more airplanes from the United States than any other beneficiary.

The report listed actual Lend-Lease exports through June as $9,882,000,000, distributed as follows: United Kingdom, $4,458,000,000; Russia, $2,444,000,000; Africa, Middle East, and Mediterranean area, $1,363,000,000; China, India, Australia, and New Zealand, $1,133,000,000; and other areas, $484,000,000. The following details were given concerning Lend-Lease in various areas:

Russia.—Without waiting for a third protocol agreement covering the year ending June 30, 1944, Lend-Lease aid continues, with July shipments at a "high level" and August's volume expected to reach a record. About fifty-seven per cent of goods sent Russia have been airplanes, tanks, guns and other munitions. More than one-quarter of the total exports —over 1,300,000 tons—has been food.

United Kingdom.—Total aid to June 30th was $4,458,000,000. The United Kingdom has received approximately forty-five per cent of all Lend-Lease exports, but only thirty-three per cent of Lend-Lease munitions.

China, India, Australia, and New Zealand.—Approximately seventy per cent of Lend-Lease shipments to China and India have been munitions. New supply routes for China are being planned and "steps have been taken to make India a great supply base for operations against the Japanese." Approximately sixty-one per cent of shipments to Australia and New Zealand have been munitions.

Ordnance Conservation.—By constantly reducing manufacturing costs on many military items and conserving critical raw materials, the Ordnance Department is saving American taxpayers millions of dollars every month. When the Army pays less for guns, tanks, and ammunition, the taxpayer's burden is less heavy.

The cost for the entire gun mount of a caliber .50 antiaircraft machine gun, for example, has been reduced fifty per cent. The cost of one part of this gun was slashed from two dollars to thirty cents. The manufacturing cost of another part was cut more than eighty per cent. In addition to cost reduction, the Ordnance Department is conserving millions of pounds of critical materials due to various conversions and redesigns. For example, shipping bands for bombs, formerly made of steel, are now made of paper.

On the basis of Army requirements for 1943, Ordnance estimates that sufficient aluminum will be released to build over 20,000 fighter planes, sufficient copper for 4,000,000,000 extra rounds of caliber .50 aircraft ammunition, and enough steel for the construction of 31,000 railroad oil tank cars. Of the other scarce metals, some 64,000,000 pounds of nickel, 4,300,000 pounds of molybdenum, 17,500,000 pounds of chromium, and 5,200,000 pounds of tin will also be released and made available for the production of other war matériel.

Cost-reduction and metal-conservation suggestions originate in hundreds of facilities engaged in the manufacture of ordnance matériel in every part of the United States. They are first screened and processed by 112 industrial experts in the 13 Ordnance procurement districts. The suggestions are then forwarded to Ordnance engineers in Washington for final approval and adoption. Thus far, 2,906 suggestions have been received, 2,339 have been processed, and more than 50 per cent are now in production.

General Marshall's Report

An Editorial

THE recently issued biennial report of Gen. George C. Marshall, Chief of Staff of the United States Army, covering the period from July 1, 1941, to June 30, 1943, is a masterly review of those important events, open to public discussion, which affected the United States Army during that time. It has been submitted "while America is at war to permit a better understanding of the great offensive operations now in progress."

A former similar report covered the period from July 1, 1939, to June 30, 1941. This was divided for purposes of discussion into two phases. The first included the fall of France and discussed "the period of national uncertainty as to the influence of the war upon the United States." The second began with the commencement of the Battle of Britain and ended with the German declaration of war upon Russia. During this phase, there was a growing national appreciation of the seriousness of the international situation resulting in a limited mobilization of our citizen army, large appropriations by Congress for the development of the military establishment, and an orientation of our industry to speed up the peacetime production of munitions of war.

The present report discusses a third and a fourth and the beginning of a fifth phase. The third phase covers the period until the Japanese attack upon Pearl Harbor which abruptly brought us into the fourth phase covering "the complete mobilization of the power of the United States and its coordination with that of our allies." This was a period when of necessity the United Nations were compelled to assume the defensive while mobilizing their power for a global effort. This ended in August 1942 with the defeat of the Japanese at Guadalcanal and Tulagi. The fifth phase, in which the allies are now engaged, is that of the offensive. It will last until the enemy is conclusively defeated.

The report itself must be consulted for the details of what is so briefly sketched above. From it one can get an appreciation of the grand strategy of the allies and an authentic background for the general tactical and logistical situations.

From the very different and more limited viewpoint of an Association devoted to industrial preparedness, certain matters need pointing out. One thing, perhaps not even yet generally known to our members, is the degree to which the saving of Great Britain after Dunkerque hinged upon action taken by the United States. The following is quoted from General Marshall's report:

"(The substance of the following paragraph for secrecy reasons could not be included in my biennial report of June 30, 1941.)

"Immediately after Dunkerque in 1940, the British Isles were in effect defenseless so far as organized and equipped ground forces were concerned. Practically all their field-army equipment had been lost, and an immediate invasion was threatened. In this situation, Lee-Enfield rifles, Browning automatic rifles and machine guns, 75-mm. artillery, with limited ammunition and TNT of the World War stock were hurriedly released to the British in return for immediate contracts to be let in the United States for modern matériel. For the United States the military issue immediately at stake was the ability of the British Fleet to dominate the Atlantic. These releases left us with World War stocks of matériel of the types mentioned sufficient to equip 1,800,000 men, with quantity production to be under way in time to meet additional troop requirements. Incidentally, at this time great Lend-Lease shipments to Great Britain, Russia, China, and our other allies were unforeseen."

What was given to England, of course, depleted our war reserves to the same extent and threw an additional and unanticipated burden upon our industry.

THE situation with respect to munitions during the third phase is stated by General Marshall in the following terms:

"On all the fighting fronts the allies were in a desperate situation due to lack of adequate matériel while facing an enemy who possessed an abundance of the most modern equipment conceived at that time. The trying problem of the War Department was to meet the urgent necessities of critical fronts without jeopardy to the security of continental United States. Money in large appropriations had been made available but not available was the time in which to convert this money into munitions ready for issue.

"The Lend-Lease Act was passed in March 1941, but it was not until the latter part of that year that it began to be effective in its results. An agreement for aid to Russia in cooperation with the British was implemented in October and was just becoming effective when we entered the war as a belligerent. In spite of our situation, it was vital that we help both Russia and the United Kingdom for our own security. This matter was considered so important that Lend-Lease aid continued throughout the crisis of our entrance into the war without notable interruptions except in the case of a few critical items."

Another and even more startling fact is to be read between the lines of the report. Although our peacetime industrial planning had no more anticipated the necessity of supplying munitions to our allies in the enormous quantities which has been found necessary than it had the diversion of our reserve stocks to England, and although a longer time is required to get the industry of a country into war production than to mobilize its man power, there is very little indication that our troops have ever seriously lacked for essential ordnance since Pearl Harbor.

The success with which the production of ordnance was established in this country constitutes a remarkable tribute to the essential soundness of the basic organization and the high quality of the war planning done by the Industry-Ordnance team from 1921 on. This was initiated by Maj. Gen. C. C. Williams when Chief of Ordnance and was under his centralized control and that of succeeding Chiefs of Ordnance. However, the operation of the Ordnance Department was decentralized under the district system with each district exercising authority commensurate with its responsibilities, under the direction of a district chief familiar with industrial problems. To have attempted to standardize the operations of the districts under a central control would have been analogous to an attempt to standardize the shoes for a company of soldiers at a given size and width.

All this has had the full coöperation and support of the Army Ordnance Association and its members for the past twenty-four years. Their loyalty will continue in the future.

Association Affairs

Rocky Mountain Post

Maj. Gen. Russell L. Maxwell, commander of the Army Service Forces Unit Training Center at Camp Ellis, Ill., and commander of the American Forces in the Middle East until last February, was the guest of honor at the second annual dinner of the Rocky Mountain Post of the Association held in Denver, Colo., on July 1st. An account of the meeting was not received in time for inclusion in the last issue of Army Ordnance so it is published herewith.

More than 300 members and guests of the Post attended the dinner, which was held in the Lincoln Room of the Shirley-Savoy Hotel. Col. Merle H. Davis, chief of the St. Louis Ordnance District, was toastmaster. General Maxwell, long a member of the Association, and editor of Army Ordnance during 1925-1926, spoke as follows:

"It seems that somehow, somewhere, most of the time, people have got to fight. We haven't been educated out of this idea, so it is important to make the contest worth while. Everywhere nations have been looking inward. If the present war is to be justified by the future, we've got to begin to realize that people are people and that opportunity is the right of all who want and can take it. In other words, we the people and our leaders must realize the importance of a sound economic structure and the responsibility of the strong to the weak, of the rich to the poor, and so on."

In spite of the complaint of some men in the American armed forces to the effect that this or that talent or ability is wasted, General Maxwell declared "no army on earth is more anxious than ours to have its classifying department function one hundred per cent. I have two sons in the service so I know what the boy in the ranks thinks about and feels. One doesn't adjust in a flash to any condition. We're doing a fine job in insuring a good fit.

"The sooner we begin to realize that we can't leave the world out of our thinking, the sooner we emphasize our relations in this world, the quicker we should start toward a peace that will perhaps justify the cost."

Speaking of our ordnance matériel in the African theater, General Maxwell said:

"American ordnance met the severest test it has ever met in the Middle East. There were dust and sand and heat and cold and rain and mud, and I don't think you'll ever find anywhere from Alaska to Cape Hope a severer test for American ordnance. We had 105-mm. howitzers, which the British, whom you understand we were supporting all this time, called 'the priest.' Then we had three kinds of medium tanks, with 75-mm. guns, which the British called 'the Shermans,' 'the Grants,' and 'the Lees.' Then we had the light tanks armed with 37-mm. guns which the British called 'the Stuarts,' after Jeb Stuart. Later, when they saw them work, they changed the name to 'the Honey.' In brief, our ordnance was just 'swell.'"

At a meeting held by the members of the Post in conjunction with the annual dinner, the following officers were elected for the 1943-1944 term: John G. Gates, president; Charles O. Voigt, vice-president; Benjamin C. Essig, D. B. Campbell, N. H. Orr, H. R. Silver, Lieut. Col. Seth Wiard, J. D. Maitland, L. F. Quigg, and A. T. Twing, directors; Capt. James Colasanti, secretary-treasurer.

Between June 1942 and July 1943 the membership of the Post has increased approximately 300 per cent—there now being about 400 members on the Post roster. The Post, which received its charter on June 10, 1942, was the nineteenth local chapter.

Ordnance Officers Honored

Eight commissioned officers and one noncommissioned officer of the Ordnance Department recently have been awarded the Legion of Merit for exceptionally meritorious conduct in the performance of outstanding service, and one commissioned and two noncommissioned Ordnance officers have been awarded the Soldier's Medal for heroism. The Legion of Merit was awarded to the following:

Brig. Gen. Alfred R. Glancy.—The citation accompanying General Glancy's award states that the Tank-Automotive Center was created in August 1942 to weld the functions of the old Motor Transport Division, Quartermaster Corps, with those of the Tank and Combat Vehicle Branch of the Ordnance Department. General Glancy was selected as its head. "Through his untiring efforts, organizational ability, intimate knowledge of the automotive industry, and high qualities of leadership, he accomplished this task in a highly commendable manner, evidenced by increases in acceptance of vehicles of thirty-six per cent efficiency of tank depots and in maintenance and supply operations due to bringing the supply of spare parts current with delivery of vehicles. In the establishment and operation of the Tank-Automotive Center, General Glancy has made an outstanding contribution to the war effort."

Brig. Gen. Elbert L. Ford.—General Ford was cited for outstanding service from February 1938 to June 1942, as officer in charge of production engineering and planning and as works manager at Springfield Armory, for developing plans, machinery, and equipment "to increase enormously the production of the United States rifle, caliber .30, M1" popularly known as the Garand.

Col. S. P. Huff.—"Through his untiring efforts and initiative," his citation reads, "he has directed development of and is largely responsible for the present successful employment of minimum-altitude bombing by the United States Air Forces. Because of his unceasing efforts in the accumulation of accurate data and in guiding the necessary tests to develop this tactic, the Army Air Forces now has for its use a valuable tactical procedure."

For many years Colonel Huff evidenced a keen interest in minimum-altitude bombing, sometimes popularly referred to as masthead or skip bombing. He was convinced that bridges, railroad yards, and factory buildings could be effectively attacked by low, fast-flying planes. The major obstacle was the development of a reliable time-delay fuze that would make it possible for the plane to drop demolition bombs at low altitudes and yet allow sufficient time for the plane to leave the danger zone created by the bomb blast.

By 1937 this land problem was solved and eventually used against Tokyo, and Colonel Huff began to urge low-altitude naval bombing. It was his idea that a bomb would take a short interval to sink before it detonated, thus permitting the airplane to reach a safe distance.

Eventually, bombs were successfully launched against lightly and heavily armored vessels at 50 feet from planes flying at 250 miles an hour—the Bismarck Sea technique. Colonel Huff then suggested the use of a sight that improved accuracy so greatly that minimum-altitude bombing is today one of the most effective ways of destroying fast-moving heavy tanks. Colonel Huff is at present serving as Ordnance Officer in the Army Air Forces Proving Ground Command at Eglin Field, Fla.

Lieut. Col. John R. V. Dickson.—It was Colonel Dickson who made possible—with such outstanding results—the application of Colonel Huff's skip-bombing technique in the Bismarck Sea engagement. His citation states he received the award for "exceptionally meritorious conduct in the performance of outstanding service in New Guinea from January 16, 1943, to March 4, 1943. As Ordnance Officer of the Advance Echelon, Fifth Air Force, Lieutenant Colonel Dickson was charged with the difficult and important task of devising, developing, testing, and manufacturing a bomb fuze which would enable our bombers safely

and effectively to attack enemy surface vessels from extremely low altitudes. Although handicapped by lack of ordinary manufacturing facilities and forced to use simple field equipment, Lieutenant Colonel Dickson overcame all obstacles and succeeded in obtaining the desired result only forty-eight hours before the Bismarck Sea engagement. When it was reported that an enemy convoy was approaching, he worked unceasingly to prepare sufficient fuzes for the highly successful action, thus, by his energy and ingenuity, making a great contribution to this signal victory."

Col. Lucian B. Moody.—Colonel Moody was awarded the Legion of Merit for "the performance of outstanding services as Ordnance Officer, First Army and Eastern Defense Command. Coming to the First Army at the time of its organization, he fulfilled with outstanding success a difficult mission of organization and control by means of his careful and intelligent planning. As Ordnance Officer of the First Army, during the First Army maneuvers in 1941, he devoted long hours and unceasing efforts to the preparation, execution, and supervision of the plan for Ordnance supply. Many features of his plan marked distinct advances in the techniques of using simulated ammunition in maneuvers. Through its operation the troops participating gained better training in ammunition supply than that acquired in any previous maneuvers, and, through his leadership and outstanding ability, Colonel Moody developed the Ordnance organization of the First Army to a high state of efficiency."

Col. Ernest A. Suttles.—Colonel Suttles received his award for "rendering services of outstanding value to the allied cause." Aided by a staff of 10 Ordnance officers and 155 Ordnance combat mechanics, Colonel Suttles planned and supervised the installation and operation of 5 motor-vehicle assembly plants in North Africa. Despite language difficulties, French troops—Spahis, Senegalese, Chasseurs, and the serious and well-disciplined French Youth Organization—were quickly trained for assembly-line operations. The five plants were planned, improvised, and placed in operation in eight days. They assembled 7,000 vehicles in 3 weeks.

Two assembly lines were equipped to assemble a 2½-ton truck every 2½ minutes. Smaller trucks were assembled in excess of 70 a day. Trailers were assembled at the rate of 140 a day. The "Jeep Orchard" harvested as many as 275 a day. Twelve-man crews unboxed and assembled jeeps at the rate of one every 9½ minutes. Over 1,000 tanks, tank destroyers, armored scout cars, and half-tracks were unboxed, serviced, tested, and placed on the road in less than ten days.

In 1940, Colonel Suttles organized the Army Motor Vehicle Inspection Service, with headquarters in Detroit, which in 1941-1942 inspected, road-tested, and shipped more than 2,500 vehicles a day overseas to American and allied troops. In 1942, Colonel Suttles was one of a group of officers sent to England to organize a motor-transport service. He accompanied the North African invasion forces to Oran in November 1942 and established the first vehicle-assembly plants in that theater.

Maj. William F. Register, Jr.—Major Register was chief of the Supply Division, Hawaiian Ordnance Depot from February 24, 1941, to July 30, 1942. The citation accompanying his award states that "during the period Major Register was in charge, the Supply Division experienced the greatest Ordnance supply activity in its history, due to the large increase in the number of troops in the Hawaiian Department and the necessity of furnishing them with new types of armament. By his energy and untiring zeal he insured to those troops a prompt and constant supply of Ordnance materials. It was largely due to Major Register's planning and organizing the work of the Supply Division that his division was able to operate so successfully when it was called upon to meet the demands that were made upon it on December 7, 1941, and the period immediately following. Major Register performed his duties in such an outstanding manner as to contribute greatly to the Ordnance supply mission in the Hawaiian Department."

Capt. Harold W. Beard.—The citation accompanying Captain Beard's award states that it is for "exceptionally meritorious conduct in the performance of outstanding service in a position of responsibility during the period from August 10, 1942, to February 1943. He effected the organization and established the operation of a central distribution system for petroleum products throughout the Hawaiian Department. Also, in connection with the many increased demands on both the Army and Navy for vital transportation facilities and special transportation equipment, his material assistance with the design, the supervision of the local construction, and his suggestions for improvements in the operation of all types of transportation equipment resulted in the solving of many problems of transportation that proved of great value to the services and effected the saving of much time in the accomplishment of many projects."

Tech. Sgt. Adam Asman.—Sergeant Asman, attached to the Armored Command, received the Legion of Merit for "exceptionally meritorious conduct in the performance of outstanding services as shop foreman of an Ordnance detachment on special duty. His thorough knowledge of motor transport, combat and utility vehicles, and his application of this knowledge contributed to the steady operation of the vehicles under test. His direct and efficient supervision of all maintenance work conducted during these tests was outstanding and materially contributed to the successful accomplishments of the detachment's mission."

The Soldier's Medal for heroism was awarded to the following:

2nd Lieut. Henry J. Putnam, Jr.—On April 26, 1943, Lieutenant Putnam rescued four people from an automobile which had crashed while rounding a curve. The car was balanced precariously on a stone wall at the foot of an embankment, live high-tension wires which had been knocked down whipped across the machine, and gasoline poured from the damaged tank.

Sgts. Charles L. and Frank V. Wessler.—The Wessler brothers, both of the Ordnance Department, were awarded the Soldier's Medal for rescuing a soldier from drowning on June 5, 1943, near Nawiliwili Beach, Hawaii.

CHANGE OF MAILING ADDRESS

READERS of ARMY ORDNANCE who change their address should notify the editorial offices, 705 Mills Building, Washington 6, D. C., at least three weeks before the publication date of the subsequent issue. If readers have notified the Association of their proper address within the specified time and still do not receive their copy, they must make claim for the missing copy within two months after scheduled publication. Claims for missing copies made later than two months after the publication date cannot be honored, as extra copies are usually exhausted by that time.

The present issue of ARMY ORDNANCE completes Volume XXV. The index for this volume, arranged alphabetically by subject and author and with title page for binding, is now in preparation and may be obtained when available upon request to the editorial offices. This index will cover subjects in the July-August 1943 issue (Vol. XXV, No. 139) to the November-December 1943 issue (Vol. XXV, No. 141), inclusive.

NECROLOGY

NOTICE has been received of the deaths of the following members of the Association: H. C. Baylis, Detroit, Mich.; J. R. Dangler, Washington, D. C.; H. W. Fletcher, Houston, Tex.; Maxwell P. Hellman, Great Neck, N. Y.; Joseph W. Henszey, State College, Pa.; Reuben Hill, Los Angeles, Calif.; L. S. Horner, New Haven, Conn.; Francis P. Kennedy, Granite, Md.; Frank J. Lanahan, Pittsburgh, Pa.; Frank A. Lawler, Chicago, Ill.; John K. MacGowan, New York, N. Y.; David Miller, San Francisco, Calif.; Joseph J. O'Brien, Webster Groves, Mo.; Earle D. Parker, Rockford, Ill.; Charles H. Perry, Waterbury, Conn. To their relatives and friends, ARMY ORDNANCE, on behalf of the Association membership, extends condolences.

Ordnance in Review

The Machine Gun—The Period of Recognition, Part V

Lieut. Col. Calvin Goddard

MOST American military men are dimly aware of the fact that the United States Army possessed some machine guns prior to the Spanish-American War—and are equally hazy as to what was done with them. Such uncertainty is warranted, since the Army itself seems to have been quite dubious as to the uses to which these weapons should be put. Distributed, apparently according to no considered plan, to the various military establishments then existing throughout the continental United States, their maintenance was the duty of the local Ordnance officer. The post commander appears to have been without specific instructions as to their employment, and, unless he possessed a native curiosity concerning their characteristics and potentialities (which was rarely the case), they remained wholly unused from the beginning of his tour of duty to the date of its termination.

On rare occasions they *were* brought out, dusted off, and even employed on military missions (against hostile Indians). But for each instance wherein they were so used there were apparently scores of others in which no thought was given to their tactical possibilities, or, if given, quickly discarded. In many instances they were wisely left behind for, mounted as they were on heavy wheeled carriages patterned after those adapted to the field guns of the period (1870-1890), they obviously retarded the movements of such cavalry units as were commonly charged with overtaking and destroying roving bands of Indian raiders. Thus Custer had left behind, long before he made his final stand near the Little Big Horn, the Gatlings which had accompanied his command when it embarked upon its fatal journey. Had he held on to them instead, the story might have had a very different ending.

Although the Gatling is the only machine gun which the U. S. Government acquired in quantity during the years following the Civil War and preceding the Spanish-American, specimens of other types were purchased and given service tests. Here it may be of interest to list the figures on machine guns procured and issued to the Army over the period 1872-1890 as taken from the official reports of the Chiefs of Ordnance for those years.

Year	*Procured*	*Issued*
1872:	.....	17 Gatlings (½-inch & 1-inch)
1873:	.....	2 Gatlings, cal. .50 1 Gatling, 1-inch
1874:	57 Gatlings (assumed to be cal. .45)	3 Gatlings, 1-inch 2 Gatlings, 1-inch* 12 Gatlings, cal. .45*
1875:	8 Gatlings, cal. .45	1 Gatling, 1-inch 5 Gatlings, cal. .50 4 Gatlings, cal. .45
1876:	48 Gatlings, cal. .45	11 Gatlings, cal. .45 1 Gatling, 1-inch
1877:	19 Gatlings, cal. .45 1 Hotchkiss revolving cannon, 1.5-inch	19 Gatlings, cal. .45 2 Gatlings, cal. .50 1 Gatling, 1-inch
1878:	17 Gatlings, cal. .45 (5 bbls.) 11 Gatlings, cal. .45 (10 bbls.) 1 Lowell, cal. .45	13 Gatlings, cal. .45 2 Gatlings, cal. .50 2 Gatlings, 1-inch
1879:	1 Gatling, 1-inch 14 Gatlings, cal. .45 4 Hotchkiss revolving cannon, 1.5-inch 10 Lowells, cal. .45	8 Gatlings, cal. .45 (10 bbls.) 4 Gatlings, cal. .45 (5 bbls.) 1 Gatling, cal. .50 1 Gatling, 1-inch 2 Hotchkiss, 1.5-inch 3 Hotchkiss, 1.65-inch
1880:	15 Gatlings, cal. .45 (10 bbls.)	9 Gatlings, cal. .45 (10 bbls.) 2 Hotchkiss, 1.5-inch 8 Hotchkiss, 1.65-inch
1881:	.....	7 Gatlings, cal. .45 (10 bbls.) 2 Gatlings, cal. .45 (5 bbls.) 4 Lowell guns 3 Gardner guns
1882:	2 Gatlings, cal. .45 (10 bbls.) 4 Hotchkiss, 1.5-inch	4 Gatlings, cal. .45 (10 bbls.) 4 Gatlings, cal. .45 (5 bbls.) 7 Hotchkiss, 1.5-inch 2 Gardners, cal. .45
1883:	1 Hotchkiss, 40-mm. 4 Hotchkiss, 37-mm.	1 Gatling, cal. .45 (5 bbls.) 4 Gatlings, cal. .45 (10 bbls.)* 4 Hotchkiss, 1.5-inch
1884:	25 Gatlings, cal. .45 (10 bbls.) 1 Hotchkiss, 47-mm. 1 Hotchkiss, 53-mm. 1 Lowell, cal. .45	6 Gatlings, cal. .45 (10 bbls.) 2 Hotchkiss, 1.5-inch 1 Lowell, cal. .45*
1885:	32 Gatlings, cal. .45 (10 bbls.) 1 Hotchkiss, 57-mm.	4 Gatlings, cal. .45 (10 bbls.) 9 Gatlings, cal. .45 (10 bbls.)*
1886:	25 Gatlings, cal. .45 (10 bbls.)	3 Gatlings, cal. .45 (10 bbls.) 1 Gatling, cal. .45 (5 bbls.) 20 Gatlings, cal. .45 (5 bbls.)*
1887:	20 Gatlings, cal. .45 (10 bbls.) 6 Hotchkiss, 37-mm. 5 Gardners, cal. .45	5 Gatlings, cal. .45 (10 bbls.) 9 Gatlings, cal. .45 (10 bbls.)* 1 Hotchkiss, 1.5-inch
1888:	.....	14 Gatlings, cal. .45 (10 bbls.) 6 Gatlings, cal. .45 (10 bbls.)*
1889:	.....	6 Gatlings, cal. .45 (10 bbls.) 8 Gatlings, cal. .45 (10 bbls.)* 1 Gatling, cal. .45 (10 bbls.)†
1890:	18 Gatlings, cal. .45	1 Gatling (10 bbls.) 4 Gatlings (5 bbls.) 10 Gatlings, cal. .45 (10 bbls.)* 3 Gatlings, cal. .45 (10 bbls.)†

*Issued to militia. †Issued to college military units.

SOME Gatlings had been procured prior to 1872 as evidenced by the issue in that year, during which none were procured, of seventeen of these weapons lumped together in the record as of "½-inch and 1-inch caliber." Arbitrarily assuming, for the purpose of estimating totals, that nine of these were of ½-inch bore and eight of 1-inch, we find that, over the period 1872-1890, the following numbers of machine guns were procured and issued:

	Procured	*Issued*
Gatlings, cal. .45	311	212
Gatlings, cal. .50	0	21
Gatlings, 1-inch	1	20
Lowells, cal. .45	12	5
Gardners, cal. .45	5	5
Hotchkiss, 37-mm. & 1.5-inch	19	11
Hotchkiss, 40-mm. & 1.5-inch	1	0
Hotchkiss, 47-mm. & 1.5-inch	1	0
Hotchkiss, 53-mm. & 1.5-inch	1	0
Hotchkiss, 57-mm. & 1.5-inch	1	0
Hotchkiss, 1.65-inch (about 42-mm.)	0	11

The discrepancy in the figures on the 1.65-inch Hotchkiss gun, none of which were procured but eleven of which were pulled out of the air and issued—we shall leave to the reader to compose! In the case of the Gatlings, it will be remembered that some were procured prior to 1872 and issued during or after that year as reflected in the table above.

A study of the totals listed above reveals the fact that, considering the size of our minuscule Army of the period, we were reasonably well equipped with machine guns. But the concept of this weapon as an *artillery* piece still persisted and was destined to retard its proper tactical employment for some time to come.

Of the machine guns current in the United States over the period under consideration, the Lowell appears to have been the only one produced in appreciable quantity, no specimen of which was purchased by the U. S. Government. This appears strange in light of the recommendation of a board of officers which gave

Colonel Goddard is chief of the Historical Section, Office of the Chief of Ordnance, and a member of the board of editors and advisers of the Encyclopædia Britannica.

that weapon extensive tests in 1877, reporting that: "In view of the favorable results of the trials at Sandy Hook, the board recommends that a number deemed sufficient by the Department of the .45-inch caliber guns be procured from the Lowell Gun Company, with all the latest improvements, and sent to Watervliet Arsenal to be mounted on gun carriages adapted for them and that the guns and carriages suitably equipped be put in the field for comparison with other machine guns now on trial in service."

A Taylor gun, several types of which have been described in previous papers of this series, was similarly tested in 1878. It evoked the following comment from the board: "The Taylor battery-gun is an ingenious and promising machine gun, but with the present arrangement for feeding the cartridges it does not compete favorably with other better perfected machine guns that have been offered for test before the board. It is probable that a more perfect feed can be effected for the service of this gun by the inventor; until this is accomplished, however, the board cannot recommend the procurement by the United States of any of these guns for service."

The Lowell weapon will be discussed in the next, and concluding, paper of this series. For the moment, the reader is requested to bear with one of the author's many digressions (which arise from the fact that the preparation of these articles has been, of necessity, an intermittent effort, new data on guns previously touched upon coming constantly and unexpectedly to hand) and allow him to revert to the Vandenburgh "volley gun," considerable reference to which has already been made (see ARMY ORDNANCE, March-April 1942, Vol. XXII, No. 131, p. 767). It will be recalled that General (?) Vandenburgh appears to have been a resident of New York State whose invention was manufactured in England and marketed to the Confederacy. That he was nevertheless willing, nay anxious, to distribute his product among the Federal forces as well, is apparent from the following letter, written by Brig. Gen. George D. Ramsay when Chief of Ordnance and printed on pages 277-278, Volume III, of "Ordnance Reports" (Government Printing Office, 1890):

Ordnance Office, War Department
May 5, 1864

Hon. E. M. Stanton, Secretary of War

Sir:

I have the honor to acknowledge the reference to this office of a letter from Mr. Vanderburgh [*sic*] in relation to his . . . guns with instructions to report, and on this subject have to state that Mr. Vanderburgh, in a letter dated London, January 8, 1864, apprises the Secretary of War that he will send or bring to the United States three guns which he wishes to present to the President or to the Secretary of War as an offering "to our Government and country." That they are a new kind of artillery, the most deadly and destructive for field use ever made, ready for actual service or experimental firing. On the 18th of February, 1864, the bill of lading was transmitted to the War Department and called for six cases of merchandise, consisting of three guns, carriages, and equipments. They were in this manner transferred to the United States with the request that they be employed against the enemies of the country; and if found hereafter of value, and they are worth to the country the cost of manufacture, this cost (which is not stated) may be repaid; but nothing more will be demanded, and this to be wholly at the option of Government. The freight and charges on those guns from Liverpool to New York, amounting to £43 5s. 11d., was paid by this Department.

On the arrival of these guns at New York, Captain Crispin was instructed to forward them to Washington Arsenal and Captain Benton directed to subject them to examination and trial, which was done with as little delay as possible.

Captain Benton's report is herewith submitted, in which he states in brief that in testing the guns he endeavored to carry out the views and wishes of Mr. Vanderburgh, but that he did not attempt to make any improvements, not being so instructed. The conclusions arrived at by Captain Benton were that with the ammunition furnished they are not suitable weapons for the service. That which was furnished was not sufficient to determine the strength and endurance of the guns, but from their delicate and complicated construction, and from the effect on them from the test made, Captain Benton concludes that they would not stand continuous firing. The results of the trial show that their destructive effect is not equal to that of our present field artillery. During the trial one of the carriages broke from inherent weakness. On the 19th of March nine shots were fired from the largest gun, at the eighth of which the elevating screw broke. At the close of the day Mr. Vanderburgh desired that the gun might be cleaned, as the barrels were found to be fouled from lead and burnt powder. It took one man *nine hours* to clean it properly.

In Mr. Vanderburgh's last communication he states that nothing has been done to put the guns in condition for service, and that by the terms of the transfer he asserts the right to demand their return, and, further, that no measures have been taken to ascertain with any definiteness the form and spread of the volley, and that the Ordnance Department is in a purely negative state with regard to his artillery. He therefore asks to take the guns on paying such charges as have been paid and incurred by the Government on them, unless the Secretary of War gives assurance in writing to make the guns useful, etc., and names two weeks as ample time to answer; that unless such permission is given he will expect the Government to pay the cost of the guns.

As this Department has given to this subject all the attention possible, and as the report of Captain Benton clearly shows that the guns are not so effective as our own, and as, more especially, we have not the time to devote to the correction of any defects that may exist in this system of artillery, I would respectfully recommend that the guns be returned to Mr. Vanderburgh without requiring him to refund the expenses which have been defrayed and incurred by the Government in that connection. Mr. Vanderburgh's letter is herewith returned.

Respectfully, your obedient servant,

GEO. D. RAMSAY
Brigadier General, Chief of Ordnance

EDITOR'S NOTE.—The next installment will constitute not only the last of this third series of papers on machine guns contributed by Colonel Goddard but will conclude his sequence of communications upon this topic, the first of which appeared in the September-October 1941 issue of ARMY ORDNANCE. Colonel Goddard's object has been to dispel, in some measure, the uncertainty prevailing as to types of machine guns developed over the period 1860-1885, as well as to indicate which of these saw actual service in military operations. With the advent of the Maxim self-operated gun in the mid-1880's, his story ends, machine-gun history from that date forward having received ample treatment at the hands of many capable authorities.

The first series of these articles was begun, as mentioned above, in the September-October 1941 issue of ARMY ORDNANCE; it was entitled "The Machine Gun—Its Early Applications," and was concluded in the March-April 1942 issue. The second series, "The Machine Gun—A Period of Evolution," was begun in the May-June 1942 issue and concluded in the January-February 1943 issue. Reprints of this series in brochure form are still available without charge to readers of ARMY ORDNANCE.

The present and third series of articles on "The Machine Gun—The Period of Recognition" was begun in the March-April 1943 issue and will be concluded in the January-February 1944 issue. This series also will be reprinted in brochure form, copies of which may be had upon request when available.

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How to Solve Fine Weighing in Production

Fine weighing in grains or grams requires precision scales of the highest type. Several such instruments are available. The trouble has been that they were too slow for production-line operation. EXACT WEIGHT Model UAB-9051 solves this problem by delivering accurate weighings in grains with speed of operation. The important task of weighing individual pellets can now be handled with absolute accuracy plus speed of operation demanded by modern high-speed American production methods. This scale (illustrated) is equipped with a magnetic dampener which checks lever oscillation to 4 beats, thus is capable of 15 weighing operations per minute. If you are engaged in any operation involving explosives where definite powder charges are required or individual pellet selection write for complete details. Our engineers have prepared special data on the subject.

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THERE IS NO SUBSTITUTE FOR EXACT WEIGHT
INDUSTRIAL
PRECISION SCALES

Versatile Vehicles

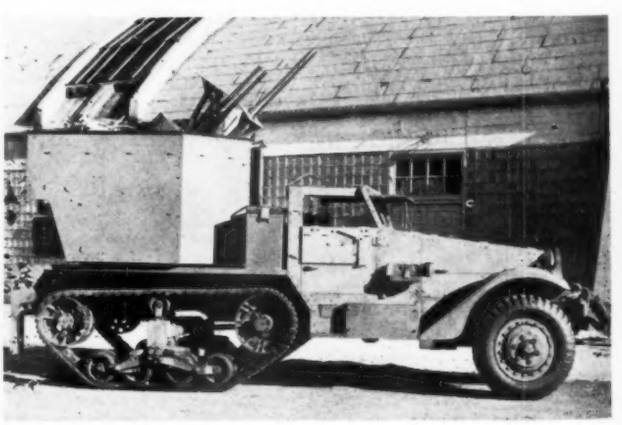
THE HALF-TRACKS PROVE ADAPTABLE TO MANY USES

CAPT. RAY P. JOHNSON

SINCE Col. J. E. B. McInerney's article, "Half-Tracks for Mobility," appeared in the September-October 1941 issue of ARMY ORDNANCE (Vol. XXII, No. 128, p. 213), the performance of this type of vehicle in actual combat has not only corroborated his statements of its mobility but has proved that it is one of the most versatile vehicles now in use by our armed forces. From the basic design there are fourteen different models or adaptations of half-tracks which have been or are now being produced in quantities. Essentially, these fourteen models can be grouped into three general classifications: personnel carriers, tank or troop destroyers, and antiaircraft gun carriages.

THE M3 HALF-TRACK PERSONNEL CARRIER

Each half-track has a specially designed commercial type front-and-rear-drive chassis with a hull of armor plate and is powered with a conventional 6-cylinder gasoline engine. Personnel carriers represent the major portion of production and usage. The M2, M2A1, and M9A1 half-track cars are fast armored vehicles with seating arrangements for a crew of ten, while the M3, M3A1, M5, and M5A1 personnel carriers are slightly larger, seating thirteen men. Both cars and carriers are armored and are protected by machine guns. The later "A1" models use a



THE M15 MULTIPLE-GUN MOTOR CARRIAGE

Captain Johnson is the Ordnance representative on the Ordnance Department's Industry Integration Committee for Half-Tracks, Tank-Automotive Center, Detroit, Mich.

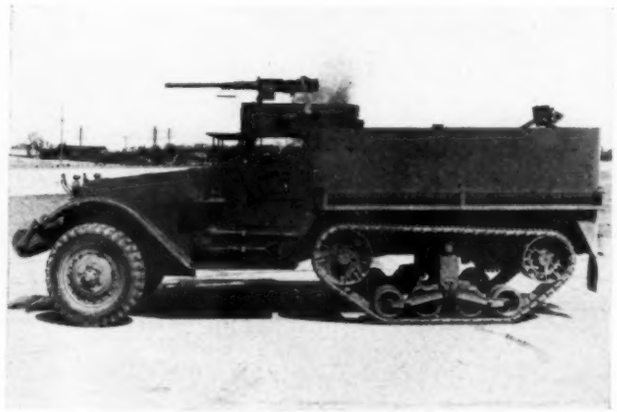
THE T30 75-MM. HOWITZER MOTOR CARRIAGE

ring-type machine-gun mount located over the right side of the driver's compartment, suitable for use against either personnel or airplanes.

The table below will assist the reader in identifying the models mentioned in this article.

MODEL	DESCRIPTION	MANUFACTURER
	Personnel Carriers	
M2 & M2A1	Half-track car	Autocar, White
M9A1	Half-track car	International Harvester
M3 & M3A1	Personnel carriers	Autocar, Diamond T, White
M5 & M5A1	Personnel carriers	International Harvester
	Tank or Troop Destroyers	
M3 (T12)	75-mm. gun motor carriage	Autocar
M4A1	81-mm. mortar carrier	White
T19	105-mm. howitzer motor carriage	Diamond T
T30	75-mm. howitzer motor carriage	White
T48	57-mm. gun motor carriage	Diamond T
	Antiaircraft Gun Carriages	
M15	Twin cal. .50 & single 37-mm. gun motor carriage	Autocar

The original purpose of the half-track was to provide a means for fast and safe reconnaissance and for quickly massing troops at distant points over soft and rough terrain. This original intention, however, has been broadened considerably through the adaptation of the half-track as a combat vehicle by the Armored Command. Before war was declared in December 1941, there were several thousand personnel carriers already in service. Lack of mobile gun carriages caused the Armored Force to consider the use of the half-track as a self-propelled mount. A number of T12's, T19's, and T30's were used at Bataan and proved their



THE M9A1 HALF-TRACK WITH CALIBER .50 MACHINE GUN

worth many times in delaying the Japanese advance. Some months later, the versatility of the half-track was again demon-

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These Practical Products Have Been Developed through Research in Colloidal Chemistry and May Be Found Applicable to Your Business.

Self-Emulsifying Safety Solvent dilutes with water to replace naphtha, gasoline, or benzine for grease-cleaning, hand-wiping operations in metals-processing plants. Contains no chlorinated compounds, has no flash or fire point and does not tend to defat the skin. (Data Sheet # 235)

Hydro-Sealed by floating water blanket, new high-performance Carbon Gum Digestive Solvent cleans carbon and paint from aircraft engine parts without harmful effect. Used hot, water seal prevents escape of solvent vapors. (Data Sheet # 236)

High-Potency Concentrate makes Self-Emulsifying Grease Solvent to remove insulating coats of grease and dirt from truck, jeep, tank, and automobile engines by emulsification and utilizing the heat of a warm engine. Cleaned engines operate more economically since original thermal efficiency is restored. (Data Sheet # 237)

Unique Oil removes salt; may be applied to metal surfaces wet with sea water. Cleans, dehydrates and leaves thin film of rust-preventive compound. Suitable as a cleaner-preservative and lubricant for small-arms bore cleaning. (Data Sheet # 238)

High-Boiling Dehydrating Oil absorbs residual water from parts, storage tanks or equipment. Recovery for repeated use made by simple heating above 212° F. (Data Sheet # 239)

Trichlorethylene Replacement . . . non-volatile cleaning and scouring solvent for large cold immersion tank . . . rinses with hot water. Long solution life. (Data Sheet # 240)

New Fuel Concentrate raises low-test gasoline to high anti-knock rating motor fuel . . . especially applicable for high-compression motorcycle engines . . . increases performance. (Data Sheet # 241)

Sparkling Clear, water-in-oil cooling compound emulsion facilitates work inspections without stopping tools in metal-cutting and grinding operations. (Data Sheet # 242)

Emulsifying Compound cleans oil from camouflage paints; restores dead, flat, lusterless surface. Shipped as a concentrate. (Data Sheet # 243)

Instrument Shampoo emulsifying solvent cleans optical lens and delicate mechanisms without harmful effect. Results in physically clean work and complete absence of any film. (Data Sheet # 244)

Fluid, Pre-Paint Cleaning extracts and emulsifies all traces of wax, oil, and grease from hard surfaces. Rinses with water . . . leaves no film. (Data Sheet # 245)

Carbon Tetrachloride Replacement . . . a methylated aromatic solvent available in open-top lever closures, 5-gallon kits including a steel dipping and drier basket. Designed for mobile unit shop, bench cleaning.

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Versatile Vehicles

strated in Africa, and a United Press dispatch told the thrilling story of how a single vehicle and its crew captured the Tunisian town of Mateur. They did it, correspondents reported, by firing two shots. Then, with that mission accomplished, the crew drove

The Half-Track 81-mm. Mortar Carrier

the half-track through the town and pounded their way onward to rescue comrades who had been under enemy fire for three days.

In an interesting article which appeared in the August 1943 issue of *Field Artillery Journal*, Col. O. W. Martin, F. A., states: "Some half-tracks in North Africa were equipped with 105's instead of standard 75's. Their heavier firepower was invaluable and their carriages stood up surprisingly well under the heavier recoil. We found these T19's very satisfactory. They traveled hundreds of miles in the United States, made many maneuvers and marches in Ireland and England and considerable distances in Africa. If maintenance, particularly first- and second-echelon, is kept up, they will go places. Its gasoline consumption is half that of the M7." Thus did the T19 half-track serve its purpose well until the heavier M7's, with 105-mm. howitzers mounted on medium tank chassis, arrived in quantity.

In the M4A1 81-mm. mortar carrier the Ordnance Department has developed a mobile high-angle-fire weapon, essentially used for firing high explosives against personnel and light matériel targets. It can also be used, however, to fire standard smoke shells and incendiaries. Little has been reported on the

The M3A1 Half-Track Personnel Carrier

performance of the M4A1 to date, but now that operations have begun in mountainous terrain, the vehicle has undoubtedly made a name for itself. The 81-mm. mortar's high angularity enables it to fire on areas that cannot be reached by flat-trajectory

Versatile Vehicles

weapons. Range of the mortar is approximately 1½ miles and the rate of fire rapid—about 30 rounds a minute.

The use of the half-track as a self-propelled antiaircraft gun mount began with the invasion of Africa. The blazing guns in

THE M3 (T12) 75-MM. GUN MOTOR CARRIAGE

the turrets of the M15's took a heavy toll of enemy planes during the landing and subsequent operations of the African campaign. As a matter of fact, some were in action before they reached the shore. One M15 alone, with its caliber .50 machine guns and 37-mm. cannon, shot down nine enemy aircraft in the course of a few days. Even before it had landed it had accounted for two of its foe, shooting one from a sea train and another from a lighter.

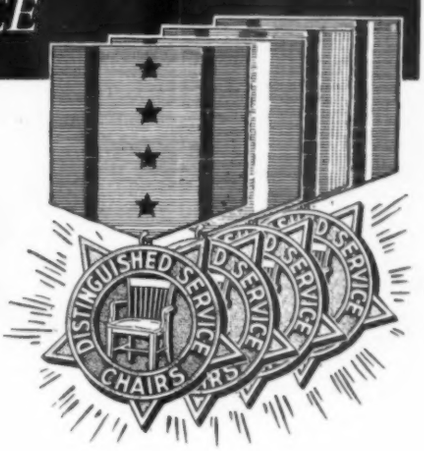
Another recent development resulting from the African campaign is the use of half-tracks and their crews for laying land mines. German mine fields proved so successful in retarding the British and American advance that we have now adopted the antitank mine, M1, as part of the standard armament on several half-track models. Special racks holding a number of mines have been built on the sides of the vehicles and the crews are trained in the art of mine laying and concealment.

Many stories are now coming back to this country from both Africa and Italy on the outstanding performance of all models now in use. When these stories can be told, they will verify the fact that half-tracks are indeed versatile vehicles well adapted to the conditions of modern combat and to all types of terrain.

THE T19 105-MM. HOWITZER MOTOR CARRIAGE

Our half-tracks are considered superior to similar types used by any of the combatant nations and have a considerably higher speed. They have a top speed of about 50 miles an hour and a cruising range of nearly 300 miles.

CHAIRS THAT GAVE DISTINGUISHED SERVICE IN FOUR WARS



Since 1868, Sheboygan Chair Company has been building quality chairs. Our chairs have won a reputation for good design and those sound engineering principles that make a chair rugged, well-balanced and comfortable.

Again we are proud to be building chairs for military use—at home and overseas, in mess halls, barracks, officers' quarters, recreation centers, and training schools. It's a stern proving ground for chair quality, and Sheboygan Chairs always stand the test.

Our diamond trade-mark is a pledge to uphold the traditional quality of our product, and a fitting symbol of this our 75th Anniversary.

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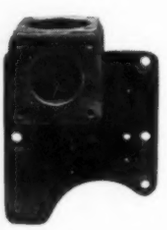
This 28-pound Gear Case, formerly made of manganese bronze, is now produced in Meehanite.

Top Gear Box, containing gears for training mechanism, was also made of manganese bronze. High strength Meehanite now used.

82 pounds of much-needed tin bronze were saved, per gun, by using Meehanite for Main Body Elevating Gear Boxes.



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From the Record

Preparations for Attack

A FEW days ago I submitted a report which pretty well covered the operations of the Army during the past two years, the why and wherefore of our various moves. There is little to add to that statement at this time except that there must be no lessening of the momentum which it has taken us three years to develop. The press and radio are keeping you well informed as to the progress of affairs in the Mediterranean and on the Russian front. You are given most of the details of the heavy bombing we are administering to the industries in Germany and the Axis satellites throughout Europe, as well as the destruction of the enemy fighter planes opposed to these devastating raids.

New Guinea, somewhat like the Aleutians, is an unhealthy locality for the enemy and his planes, barges, and soldiers. As a matter of fact, the entire western Pacific has become a critical problem for the Japanese. For the first time we are getting under way with the war as we would have it conducted, and I hope that from now on we shall rarely be on the receiving end except as is inevitable when trading punches in battle contacts.

It has seemed to me from reading the papers recently, that there is some misunderstanding as to the degree of success we have attained in the prosecution of the war. One gathers the impression that our various moves of late were the final steps in the conflict.

Perhaps it might be well for me to outline the present state of our deployment. For most of the past year and a half we have been engaged in establishing bases for future operations. Comparatively speaking, large combat forces of the ground Army have not yet been engaged. As I endeavored to show diagrammatically in my recent report, our shipping has been largely employed in getting our Air Forces into action and in building up the tremendous installations required all over the world both to maintain the combat forces already moved into the various theaters and to provide for the very much larger forces to come. These preparations have now been practically completed and it is the last-mentioned detail to which I would refer.

We have prepared in North Africa and in Sicily, and we are about to prepare in Italy, for the supply and maintenance of heavy air and ground forces. For a long time we have been making similar preparations in the United Kingdom, and throughout the Pacific the same process has been under way since January 1942. Meanwhile there has been built up in this country a formidable force of divisions and army corps with all the supporting troops—disciplined, highly trained, hardened, ready for embarkation for the great and final deployment of our armies against the enemy. Save for assaults in the air, only a small portion of our combat strength has been engaged. Now at last we are ready to carry the war to the enemy, all overseas, thank God, with a power and force that we hope will bring this conflict to an early conclusion. But please remember that this phase is just about to begin, a point which seems not to be understood by our people here at home, possibly because they are far removed from the agonies of war except for those whose sons or husbands have been engaged in the fighting.

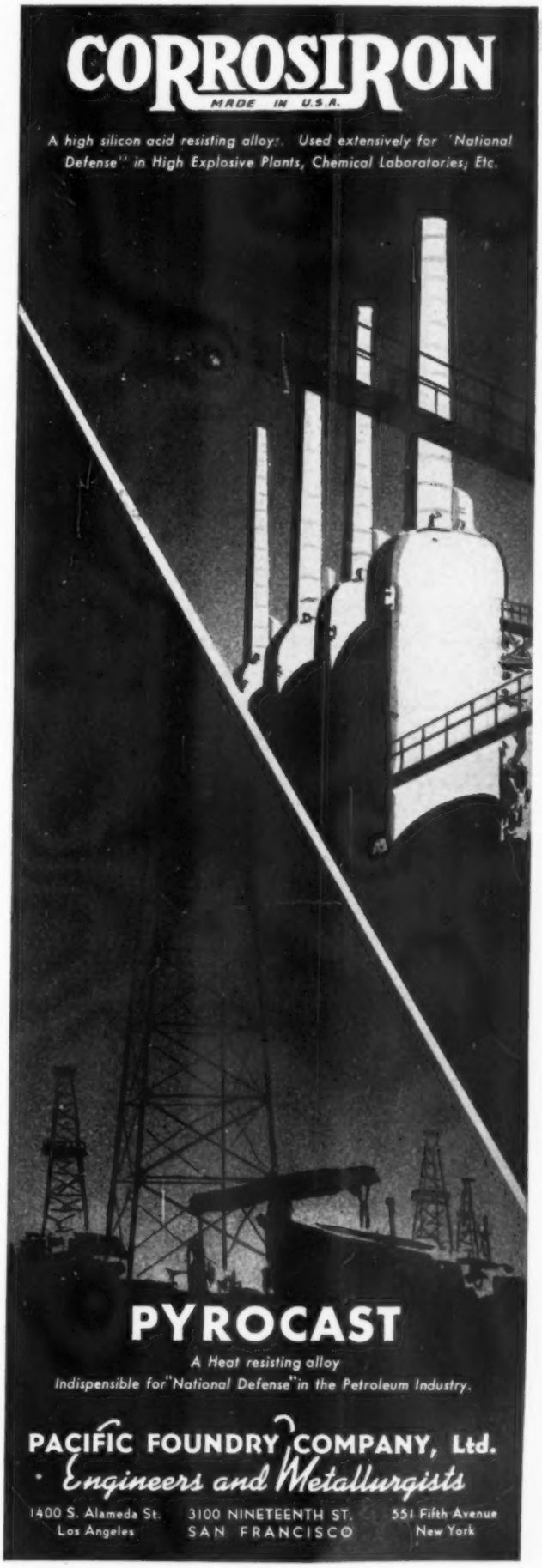
CONCERNING the public reactions of the moment, I find myself in a curious state of mind. For three years or more it has been a daily struggle of striving to meet the demands without the available means. There has been the constant problem of weighing the priorities of this theater against that one, of sending men to the front for whom training ammunition had been lacking, or similar deficiencies. Now I find myself in the position of being questioned, if not investigated, for having too much of something

or other. I don't know yet exactly what this excess is, but I do know that I am profoundly grateful that for once in the history of the United States there is suggested the possibility that we may have too much of something or other with which to support our armies. It will require considerable proof to assure me that such an unusual state of affairs actually exists. And I would add this view—my consideration is for the American soldier, to see that he has every available means with which to make successful war, that he is not limited in ammunition, that he is not limited in equipment, and that he has had sufficient training and medical care; in other words, to see that for once in the history of this country he is given a fair break in the terrible business of making war. So I must confess that rather than being disturbed by the doubts that now seem to be arising in the public mind at the present time, I am vastly relieved that they should be of that particular character rather than the usual recriminations over tragic deficiencies of every kind and nature.

There is another phase of the present situation which I believe it will do no harm to refer to publicly and probably will be of interest. . . . We have been engaged for a number of months, and very properly so, in plans for the further development of the war in the Pacific with the additional means as they become available from the struggle in the European theater. The first transfer made possible by our battles in the Mediterranean will result from the elimination of the Axis navy in that region. That means more naval power in the Pacific and that, in turn, means additional bases and equipment which have to be planned and provided for long in advance. We are similarly engaged in planning regarding other forces, particularly air, and it will probably interest you as much as it will discourage the Japanese to learn that our most difficult problem is to find sufficient bases from which to operate the vast forces which are to be poured into the Pacific for the rearrangement of the affairs of the Son of Heaven with his military clique.

Considering the fact that each day of war means both a colossal expenditure of money and a constant expenditure of human life, it is evident that we must not lose an hour in making our transfers from one theater to another. We are proceeding on the basis that nothing is to delay this flood of power to be added to the forces which already outnumber the enemy and are steadily growing stronger day by day. But I would add that these matters are not the affair of a moment, the result of a campaign of propaganda or of temporary enthusiasms or special interests. We must proceed in the most businesslike manner possible to make this war so terrible to the enemy, so overwhelming in character, that never again can a small group of dictators find a sufficient following to destroy the peaceful security of a civilized world.—*Gen. George C. Marshall, Chief of Staff, U. S. Army, before the American Legion Convention, Omaha, Nebr.*

EDITOR'S NOTE.—In an address before the "Back the Attack" exposition in Washington, D. C., General Marshall made the following statement: "In the wastage of every conceivable type of military equipment, this devastating war in which we are now engaged surpasses any in the history of the world. There is the hazard of loss in every shipment overseas, with a greatly increased hazard during landing operations. The development of the airplane, of modern automatic weapons, of rockets, and bombs of every description, combined with operations in all types of terrain and weather, jungles and icecaps, deserts and mountains, plus an enemy who is adept in every method of destruction—all this necessitates the production of staggering quantities of munitions. No previous war has approached such requirements as the present awful struggle. Tanks, jeeps, trucks, airplanes, and artillery are inevitably destroyed by the hundreds on the battlefield even when the going is good. So far we have been extraordinarily fortunate, but even so the losses present a serious problem."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Accustomed to tough work, these are the same outfits that helped prepare the ground for the speedy construction of the numerous arsenals, airports and service camps throughout the country . . . that rushed through many of the thousands of miles of our military and access roads. The story of the tractor's part in this war is interestingly pictured and related in our book "Fightin' Power". We will gladly send you a copy on request. Write for it.

YOURS FREE . . . Write for your copy of "Fightin' Power"—the story of the tractor's part in the war.

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Military Explosives

The Technique of Drying Black Powder

L. G. Powers

WITH materials and processes of manufacture changing frequently and improved Ordnance-plant methods constantly being adopted, important needs for the control of temperature and relative humidity are found in munitions work. These start with the control of the moisture in black powder and follow through in the fabrication processes of relay and delay caps, fuzes and primers, to the finished shell loading and final shell storage. Black powder is known to be temperamental, for in the drying cycle it is sensitive to temperature, air motion, and handling and has been known to explode violently on occasions where all precautions were not taken.

Black powder has not been used for some years as a propelling charge in military arms for as such it has been replaced by the more practicable, slower burning, less erosive smokeless powder. However, it is required in ignition charges for the smokeless powder in such forms as primers, relay and delay caps, and powder-train fuzes. In these applications its composition varies according to the use, but its basic materials remain essentially potassium nitrate, charcoal, and sulphur. By decreasing the charcoal and correspondingly increasing the sulphur, the rate of burning is accelerated. The basic materials of black powder are hygroscopic and quickly reach equilibrium with the moisture in the surrounding atmosphere.

There are many different forms of black powder ranging from the pelleted type to the extremely fine type, and the powder may be glazed or unglazed. It is sometimes easier to dry powder that has been glazed or compressed into pellets than it is to dry the fine powder. While moisture is harder to drive from the pellets, they are not so sensitive to air motion in drying. Therefore, the design of the drier for glazed or pelleted powders does not present the problems encountered in the design of a drier for extremely fine powder.

The amount of moisture the powder will hold when in equilibrium with the moisture in the surrounding atmosphere is called the *moisture regain* in the powder. Various tests have demonstrated the effects of this moisture on the quality and the characteristics of the powder, and have shown that there is a definite moisture regain at which optimum firing results can be obtained. Accurate timing of the shells is imperative, and controlled moisture regain assures the best shell performance. It is generally considered that powder arbitrarily exposed to the outdoor weather with resultant varying regain does not produce satisfactorily uniform results. Some method to regulate this moisture content is necessary, and the starting point is to dry the powder to a level best suited for simplified handling and to accomplish the desired final regain.

There are other reasons for drying black powder. In the loading of powder-train fuzes a fine-grained powder is used. Better flame dispersion can be had if this is first brought to an extreme dryness and then allowed to regain uniformly back to the desired moisture content. Better fuze timing and shell effectiveness result.

Drier design presents many engineering problems in the control and handling of air. It is first necessary to know the type of powder and in what quantities it is to be dried. Operations at Ordnance plants require dried black powder in amounts weighing from 10 to 10,000 pounds a day, depending upon whether the powder is to be used for relay caps, delay caps, time-ring loading, etc. Secondly, it is necessary to know from what initial moisture content and to what final moisture content

it is to be dried. For example, the regain of a powder in normal atmosphere may be 0.7 per cent, and, depending upon its use, it must be dried to 0.4 or 0.2 or to 0.05 per cent. The degree of dryness required affects the drying time. If the drying time to 0.4 per cent is 2 hours, and to 0.05 per cent is 8 hours, the drier for the latter must be several times the size of the former to dry the same quantity of powder.

Thirdly, it is necessary to know in what part of the country the drier will be operated. Larger mechanical equipment is required in the hot, moist climate of the lower Mississippi Valley than in the intermediate climate of our northern states. Fourthly, it is necessary to know the top drying temperature allowed. This top temperature is determined partly by the explosion hazard and principally by the decomposition characteristics of the powder. Drying temperatures must be held within predetermined safe limits.

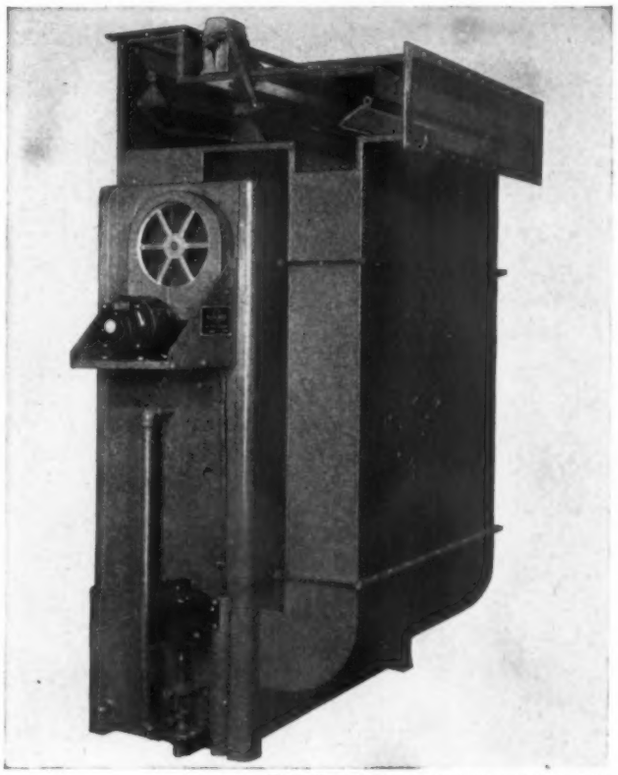
With the above data known, the design characteristics of the drier can be developed. For uniform drying, the powder must be equally distributed within the drier, and the air must penetrate to all the particles. A screen-tray-type drier lends itself admirably to shallow layers of powder and to compactness, and is the basic concept about which the drier is evolved. There are several methods by which the drying can be accomplished. One method is to raise the temperature of the air. This heats the powder and, by natural vapor-pressure differential, drives the moisture from the powder into the air. This simple method for drying might apply to products where no explosion or deterioration hazard exists, but does not readily apply to black powder where top temperatures must be limited. The extent of the drying with this method is confined, and the drying time is generally too long for practical purposes.

A second method for drying is to reduce the moisture content of the drying air. This principle is more applicable for drying black powder and is used where top temperatures cannot be exceeded. It has the advantage that the dryness of the air is regulated to a constant level, thereby eliminating the moisture variations that occur with changing outdoor weather conditions. Lowering the moisture content of the air can be accomplished by several means, but the method most generally used is that of the solid-adsorbent dehydration with such material as silica gel. This material has the unusual property of adsorbing moisture into its structure and thereby reducing the moisture content of the air passing over it. The latent heat liberated by this adsorption raises the air temperature, which is a desirable feature for any drying apparatus.

The drying rate for black powder has been determined in the laboratory, and, within reasonable limits, this drying can be duplicated in the field. With this rate, and the foregoing design data, it is possible to determine the quantity of air to be handled through the drier. Actual field experience indicates that for best drier performance the volume of air circulated through the drier is not as critical as is the dryness of the air.

The apparatus for dehydrating the air and regulating its temperature is, for safety reasons, located in a separate room or building from the actual powder drier. The air enters the mechanical apparatus, is first dehydrated, and is then heated to the desired drying temperature. This temperature is safely below the predetermined danger point and is usually 145 degrees Fahrenheit. Since steam is invariably the heating medium, and its temperature is above 212 degrees, a danger condition exists, and a safety water-cooling coil is added after the heating coil to prevent the air temperature from rising above 145 degrees. It is not always practical to insert a thermostat after the heating coil because of the possible direct radiation effect on its accuracy. In the case of the small dryers, an equalizing tank is added for locating this control instrument.

Only outside air is taken into the apparatus, for should air be recirculated and black powder allowed to accumulate gradually in the return ducts and through the air-conditioning apparatus a hazardous condition might be set up.



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Military Explosives

The air thus mechanically conditioned and automatically controlled is delivered to the powder drier. Fine powder is supersensitive to air motion, so it is necessary to distribute the air uniformly through all trays with a minimum of air motion at any one point. Air circulation should be so well controlled that the powder in the top tray will dry just as quickly as the powder in the bottom tray. To accomplish this, a dual system of vertical ducts is run inside the drier, one to supply the air through a slot entering the top side of each tray area and the other to exhaust the air through a slot from the underside of each tray area. The trays are constructed of copper screening, and a canvas cloth is placed over this screen to hold the powder. The air enters the tray area, passes down through the powder and then out through a plenum on the underside of the tray, thereby bringing the air into intimate contact with the powder and yet not stirring or carrying the powder along in the air stream.

Where extremely fine powder is handled, an additional screen is introduced above the powder tray to eliminate the effect of entrance air motion and to act as an additional resistance to assist in the uniform flow of the air down through the powder. Dampers are installed in both the supply and exhaust air ducts to prevent back drafts which might otherwise disturb the powder during the loading and unloading periods. Other refinements in the air flow are added as desired.

A powder drier must incorporate every conceivable safety feature, not only from the standpoint of the safety of the men working around the drier but because an explosion causing damage to the equipment would delay production. Safety features incorporated in the drier include sparkproof fans and sparkproof protection for all metal rubbing surfaces. Trays are brass and copper as are the expansion springs which adjust these trays for tight fit in the shelves. Door edges are brass as are the door hinges and catches. All parts of the drier are grounded to prevent accumulation of static electricity and to prevent a spark when touched by the operator. To ground the doors they are connected to the main drier frame by a brass cable. The latest drier construction incorporates door catches of the spring type so that in the event of an explosion the drier cabinet will not act as a pressure container; instead, the doors will fly open and minimize the force and damage of the blast. The internal ducts are vertical to prevent powder-dust accumulation, and a gutter at the bottom permits easy washing of the shelves which are pitched slightly to facilitate this operation. All internal ferrous parts are galvanized to prevent corrosion and rust.

The top temperature of 145 degrees Fahrenheit recommended for black-powder drying has a safety factor included before hazard starts. A study of vapor-pressure differentials shows that including an additional safety factor—for example drying at 140 degrees—will tend to slow the drying rate and lengthen the drying time. Drying power will increase more rapidly by raising the top temperature (dry bulb) than by lowering the bottom temperature (dewpoint). Lowering the dewpoint temperature of the air to 40 degrees Fahrenheit is essentially necessary, but additional lowering from 40 to 20 degrees Fahrenheit is only equivalent in drying power to raising the temperature from 140 to 141 degrees Fahrenheit. To express this in terms of drying rate, lowering the dewpoint temperature from 40 to 20 degrees Fahrenheit increases the drying rate 2½ per cent, whereas raising the dry-bulb temperature from 140 to 141 degrees increases the drying rate 2½ per cent; raising the dry-bulb temperature from 140 to 145 degrees increases the drying rate 15 per cent. Not much is gained by lowering the dewpoint temperature beyond the advisable 40 degrees Fahrenheit, whereas considerable drying power is lost in lowering the dry-bulb temperature below 145 degrees Fahrenheit.

It is known that the majority of the drying takes place in

the first two hours. For the next four or eight hours the drying progresses at a slow rate. The low point possible in this drying is determined by the moisture equilibrium between the drying air and the powder being dried. The longer the powder remains in the drier, the closer it approaches this equilibrium.

Black powder is extremely hygroscopic and the rate of moisture pickup by the dry powder is rapid and increasingly so as the weather becomes warmer and more humid. This is pertinent in understanding the need for a controlled atmosphere in the plant operations where the powder is processed after leaving the drier.

There is some question as to how far in the production line beyond the powder drier the moisture regain in the powder should be controlled. Since it is desirable that the powder reach equilibrium at a uniform rather than at a variable regain, the assembly buildings for relay and delay caps, fuze lines, and certain sections of the shell-loading line should be air-conditioned. This has been or is being accomplished at various Ordnance arsenals. At other arsenals, dry houses have been built wherein the relay and delay caps are stored to keep them from regaining moisture between processing steps. This allows a reasonable control of dryness in the final product and is a step toward uniform regain in the powder and consistency in final shell performance.

Powder from the drier is tested in the laboratory, and generally a record is kept of the moisture content in each batch as it comes from the drier and as it later comes from various operations on the assembly line. The test procedure to assist in the production must be accurate, for black powder will pick up moisture quickly.

Thus it can be seen that considerable error can occur in the laboratory if the powder is exposed to the atmosphere even for only a few moments. This can be readily observed in the arsenal laboratory dryness tests for pellets, where usual summer results show greater dryness in the powder before it is ground than after it is ground. The error is due to exposure of the powder to the humid atmosphere during the grinding.

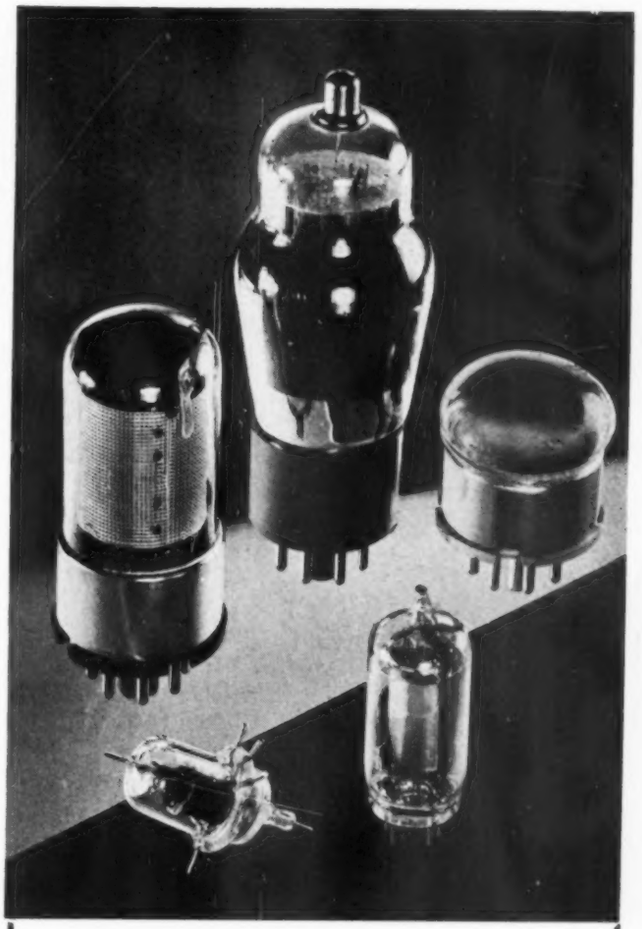
Where test samples of the powder are taken, it is well first to place the sample bottle in the drier to be sure that the air in the bottle is dry. It is also well to use a bottle of such size that it can be completely filled with powder to prevent moisture regain from air within the bottle. The bottle should be carefully sealed at the drier and should be in a dry atmosphere when opened in the laboratory. A small dehydrated test room is advisable for accurate and consistent test results.

COTTON FOR SMOKELESS POWDER

OUT of the total estimated cotton crop in the United States this year approximately 1,000,000 bales of cotton linters, each weighing about 630 pounds, are earmarked for munitions purposes. A bale of clean linters will make enough powder to shoot 100,000 bullets. Cotton is the basic ingredient in the propelling charge used in all battle weapons, ranging from the caliber .30 rifle to the mammoth 16-inch gun.

Every day thousands of bales of cotton are broken open in these Army Ordnance explosives factories and dried by hot air. The cotton is then dumped into pots containing a nitric- and sulphuric-acid solution, washed to remove the excess acid, and then purified. Other ingredients are added for stability and to eliminate the telltale powder flash that would reveal our gun positions in battle.

During the past year, ammunition plants under the jurisdiction of Army Ordnance have produced more than 1,400,000 tons of high explosives and propellent powders. During this period, more than 1,500,000 tons of bombs and over 200,000,000 rounds of artillery ammunition have been loaded with high explosives.



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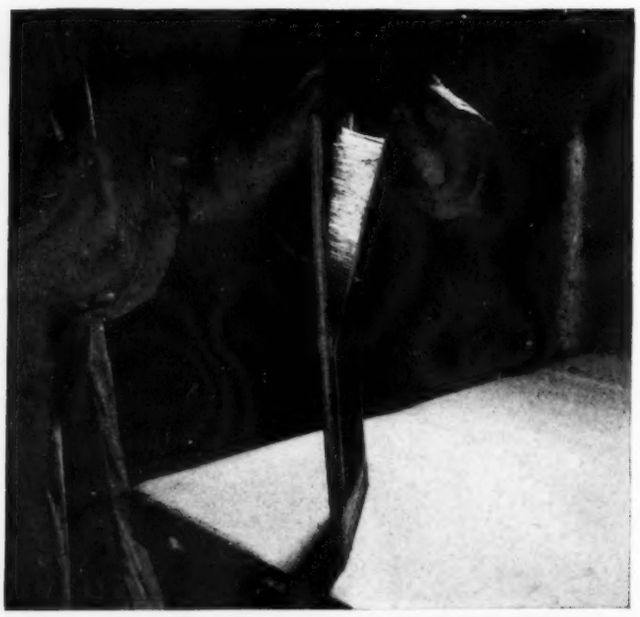

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Professional Digest

The Remington Indoor Range

THE longest enclosed firing range in the Western Hemisphere—believed to be the largest of its kind in the world—was recently erected and placed in operation by the Remington Arms Company at its Bridgeport, Conn., plant. Resembling a fallen giant obelisk, the huge concrete soundproof tunnel is 1,800 feet long—3 times the length of any other enclosed range in the country. Inside dimensions are 15 feet wide by 12 feet high, with walls 15 inches thick.

Ammunition quality today must, of necessity, be of the very highest, for many specification standards are now far more rigid than ever before in the history of the ammunition industry. Use of the range has led to quality records never before achieved. Construction of the range minimizes the hazards of testing ammunition and creates facilities for the most rigid tests to which military and sporting ammunition can be subjected.

The range is located in Remington's 337-acre park, lying partly in Bridgeport and partly in neighboring Stratford. Under present wartime conditions, areas around the park have mushroomed into thickly populated residential sections, greatly enhancing the hazards of firing caliber .50 and even caliber .30 cartridges in the usual manner on open ranges.

Constant daytime firing disturbed the rest of war workers on the night shifts, and firing at night—essential to efficient observation of the flight of tracer bullets—affected the sleep of day-shift war workers. This new range permits 24-hour testing, often necessary under heavy production schedules. Its soundproof shell hushes the roaring rattle of caliber .30 and .50 machine guns to the gentle tapping of a lead pencil on a glass-topped desk.

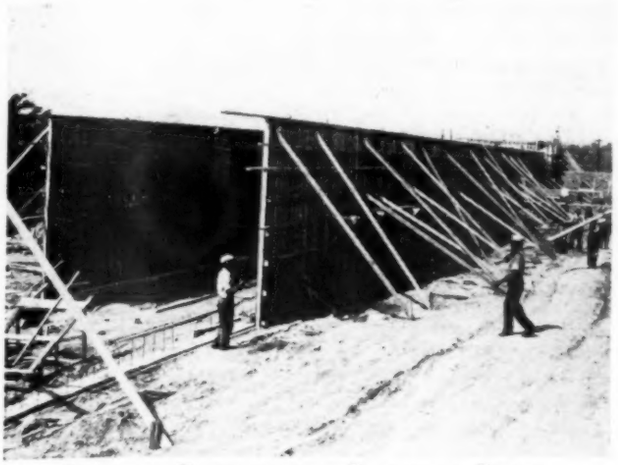
The unique range affords ideal accuracy testing conditions for every caliber of small-arms ammunition from the tiny .22, used now in military training, to the forceful .50. The only ammunition now being tested in the range is that of calibers .30 and .50, made for the U. S. Government and used on training fields and battle fronts.

THESE new facilities afford Remington's ballistic department complete and extremely accurate information concerning the performance of daily production. At present, the firing is particularly directed toward accuracy and trace measurements on caliber .30 and .50 cartridges at 600 yards. These measurements, however, could be registered on all calibers of small-arms ammunition at all ranges up to the length of the building. If desired, velocities over any distance up to 600 yards can also be determined. At muzzle velocities in the neighborhood of 2,800 feet a second, the caliber .50 bullet strikes the target 600 yards away in slightly more than half a second from the time the trigger is pulled, while the .30 speeds down the range a fraction slower.

Under the program of stepped-up production, extensive testing is necessary to insure a constant flow of the highest quality ammunition possible. Several thousand rounds are fired daily. Results of these tests and of others in laboratories and shorter ranges are used for a number of purposes. Among them are the development and improvement of products, control of manufacturing processes, and assurance to the Government of highest-quality ammunition. When Remington returns to its normal service to sportsmen, the range will be extremely valuable in the development of improvements to sporting ammunition, particularly the extreme accuracy demanded in match ammunition. While the only testing being done now is at 600 yards, shorter-distance testing could easily be provided by the use of portable

target frames. The range is now manned by twenty-two ballistic operators who work in two shifts, but it can be used for 24-hour firing when necessary.

The shooting room houses three shooting bays, each with its own telephone connecting with the target tender at the butts and also with the three tracer-observation positions on the roof. These are weatherproof turrets where observers look down through a bulletproof window in the roof of the range and perceive the flashing streak of the bullet. The glimpse is, of course, a fleeting one, but sufficient to determine the quality



PREPARING FORMS FOR THE REMINGTON RANGE

of the "trace." The windows are 12 inches wide and extend across the width of the roof. The posts are located at 125, 250, and 500 yards. Three other observation positions look in at the target end of the range.

The bullets bury themselves in the butts, which consist of forty feet of sand, backed up on three sides by 1-inch steel plate and reënforced by a 24-inch concrete wall, with another forty feet of earth on the outside. Two blowers, which inhale fresh air through two ports located midway the length of the range, eliminate gas and smoke.

The target room is located at the butts. Here trained workers measure the targets for accuracy and make tracer observation checks.

Elaborate appliances safeguard employees. The sole entrance to the range, located near the shooting room, is kept locked at all times when the range is unoccupied. The opening of this door automatically closes the firing ports, which are protected by a sheet of steel and a sheet of armor plate, the latter set at an angle. These automatically slide in front of the gun muzzles when the entrance door is opened for work inside the range.

Large portable spotlights at the shooting bays and inset roof lights at the target end light the range sufficiently for present purposes. If desired, however, portable floodlights, placed at intervals along the entire length of the tunnel, permit complete lighting.

More than 1,200 mixing-type truckloads of concrete, enough to lay foundations for 200 average-size dwellings, were required in the construction of the range.

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destruction against thick brick walls, rock masonry, structural steel, and railroad rails as it has against enemy tanks. During the North African campaign, "Bazookas" of one United States division alone destroyed at least six enemy tanks.

According to details recently released by the Ordnance Department, the "Bazooka" launcher, or gun, is a metal tube somewhat more than fifty inches in length and less than three inches in diameter. It is open at both ends. Attached to the tube are a shoulder stock and front and rear grips for the firer, together with sights and an electric battery which sets off the rocket propelling charge when the launcher trigger is squeezed. There also are safety devices. (See illustrations on p. 566.)

The launcher is operated by a 2-man soldier team—one the firer, the other the loader. When the launcher is held in firing position, the loader is at the right and rear of the firer. The launcher may be fired from any position normally used by a rifleman in combat. After the loader has inserted the rocket in the launcher, he turns a contact lever to the "fire" position, signals "ready" to the firer, and then drops down and away from the rear end of the launcher and grasps a new rocket. When the firer squeezes the trigger, the rocket propelling charge is ignited and flashes from the rear of the launcher tube.

The rocket itself is heavier than the hand grenade and is nearly two feet long. Its appearance is that of a small, elongated aircraft bomb. Its components are an explosive head, propelling-charge powder tube, and finned tail, the latter providing accuracy in flight.

The "Bazooka" supplements, rather than supersedes, other weapons. It is standard equipment for certain classes of troops. Raiding groups, tank-hunting parties, and reconnaissance elements have reported it highly effective. It has been used with success by landing parties in neutralizing pillboxes.

Armament of the Focke-Wulf 190A-3 Airplane

THE Focke-Wulf 190A-3 is one of the most interesting airplanes Germany has produced. In the first place, it is a single, coherent conception in which all details have been subordinated to the central idea. There are no signs of bits and pieces added as afterthoughts or of structural adjustments and modifications.

The armament of this airplane, according to *Aëronautics*, consists of the following guns, all fixed and firing forward: Two MG 17 guns (7.92-mm.) located on top of the engine in front of the pilot's cockpit; two MG 151 guns (20-mm.) modified to fire electrically detonated cartridges and synchronized electrically to fire through the arc of the propeller; two MG F.F. (Oerlikon 20-mm.) guns, located, one in each wing, outside the propeller arc.

The MG 17 guns are installed above the engine, one on each side of the aircraft center line, with the ammunition boxes immediately below them. The guns and the synchronizing gear are of a standard type and the ammunition belt is of the type in which the links disintegrate after the rounds are removed.

The MG 151 guns are similar to those found on previous German aircraft, but the breechblock has been modified to fire the cartridge electrically, and the ammunition itself has been altered accordingly. The principle of operation is as follows: When the breechblock is fully forward, a contact is made which allows a current to flow to the cartridge detonator. This current is controlled by a commutator connected to the engine which prevents the cartridge being detonated if the propeller is in the line of fire. The commutator is situated on top of the engine on the same block as the mechanical interrupter gear for the MG 17's.

The MG F.F. (Oerlikon) guns are of a type similar to those used in the ME 109E. The magazines are capable of holding sixty rounds. The gun chamber is heated by means of an air duct from the engine along the leading edge of the wing.

Book Reviews

THE THERMODYNAMICS OF FIREARMS. By Clark Shove Robinson. New York: McGraw-Hill Book Company. 175 pp. $2.50.

AFTER a brief historical review of the development of firearms and propellants, the author outlines basic thermodynamic principles and basic mechanics, stoichiometry, and physical chemistry. The principles and equations involved are set forth in a concise and orderly manner. A 2-page tabular summary of formulas for perfect gases, giving in one table all the applicable equations for perfect gases, is itself worth the price of the book. In the chapter on basic physical chemistry the author explains the equilibrium constant in reversible gas reactions and explains its use in determining the relative weights formed on explosion of those gases which have part in the water-gas reaction. A table gives the values of the logarithms of the equilibrium constants of these gases at various temperatures. Examples of the application of these principles are given.

There follows a chapter on the heat of explosion, one on the heat capacity of powder gases, and another on the temperature of explosion. The determination of the heat of explosion is handled in the conventional manner. Several methods of determining the heat capacity of the powder gases as they vary with temperature and pressure are given. All are based on experimental determinations of specific heats of these gases under varying conditions of temperature and pressure. In the chapter on calculation of explosion temperature, the author proceeds by a series of approximations to determine the uncooled temperature of the explosion gases from the measured temperature in a closed explosion bomb. He then determines the maximum pressure corresponding to the uncooled gases.

The author points out that the ignition of propellent powders must be by high temperature, and to secure uniformity of action it is desirable to have all surfaces of the charge ignited simultaneously. He makes the interesting suggestion that an equal-volume mixture of acetylene and oxygen would give ideal ignition conditions.

Although the historical assumption with reference to the rate of combustion of propellent powder has been that it varies with some function of the pressure, the author believes that the rate is affected principally by the temperature, as this determines the heat flow from the hot gases to the cold surface of the powder. This view has also been held by this writer and others, but, as pointed out by the author, it is much easier to determine experimentally relations between the pressure and the rate of burning than between the temperature and the rate of burning. He follows Vielle, Charbonnier, and others in the use of the pressure relation.

Useful chapters on loading density, surface factor (granulation), powder composition, recoil, rotation of projectile, friction of projectile, flash and smoke, stability of propellants, measurement of pressure, and measurement of temperature are also included. Another chapter describes the method of obtaining data from closed-chamber experiments and of analyzing these data so as to arrive at "uncooled" temperatures and pressures and to determine the rate of combustion. A short chapter is devoted to the graphical study of experimental firings and their comparison with theoretical results.

Finally, a chapter is given to the calculation of interior-ballistic curves—the objective to which all the preceding chapters have led. That, at least, would be the view of the powder designer and the gun designer. The author computes these curves by numerical integration of the differential equations involved—

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Book Reviews

the only practicable way, unless the powder is assumed to burn as the first power of the pressure, and the most practical way in any case. The book closes with a short chapter on the theory of rockets.

The author has produced a work which will be of great value to powder and gun designers and to ballisticians in general. On account of its arrangement in separate short chapters, each dealing with one feature of the subject, and the direct and simple but scientific treatment, the book will be especially valuable to students of ballistics. The writer certainly would have been glad to have had this book when he commenced the study of ballistics thirty-five or forty years ago. The author deserves credit for a valuable contribution to the literature of the science.

MAJ. GEN. W. H. TSCHAPPAT, *U. S. Army (Ret.)*

ARMORED WARFARE (An annotated edition of "Field Service Regulations III"). By Maj. Gen. J. F. C. Fuller. Harrisburg: The Military Service Publishing Company. $1.

THIS is a new edition of General Fuller's famous text, "Field Service Regulations III," first published in 1932. As Colonel Marshall in his foreword to this classical work on mechanized and armored warfare indicates, the first edition was a failure in England and the United States. Now, under the title "Armored Warfare," the text is republished at a time when not only every military man of both countries is thoroughly familiar with General Fuller's logic, but when most civilians are, too. "Field Service Regulations III" was much discussed in the pages of ARMY ORDNANCE ten years ago. Attention was repeatedly called to its importance, its soundness, and the general ignorance and apathy of most people concerning its contents. But that is an old lesson which, due to our pacifist leanings, we had to learn the hard way!

It is not necessary to review "Field Service Regulations III" again in these pages. That original text was considered prophetic by members of the Army Ordnance Association and will stand for all time as a clarion call to clear, fearless, military thinking in this mechanical age. Rather, this occasion can be taken to pay tribute to the man who so fearlessly championed the mechanization of armies at a time when the staffs of most armies were still asleep and lost in the maze of World War I thinking. General Fuller stands today as one of the greatest military analysts of our time. His forthright statements, sound military logic, and fearless analysis kept alive the principles of mechanized thought, as applied to armies, in a day when these topics were too difficult for the average military intellect to grasp.

Historian, soldier, and exponent of military mechanization, General Fuller must not be denied his rightful place among students of military progress. His writings in the pages of this journal and his many books will stand for years to come as a vindication of the soundness of his thought. If there is one man the world over who can shake his finger at the British and American Armies and say, "I told you so," that man is he. May he bring out an edition of "Field Service Regulations IV" when this war is over. If we disregard it as we did "Field Service Regulations III" it will again be to our peril. L. A. C.

REVEILLE—WAR POEMS BY MEMBERS OF OUR ARMED FORCES. Selected by Daniel Henderson, John Kieran, and Grantland Rice. New York: A. S. Barnes & Company. 254 pp. $2.

THIS book is described as a representative group of poems revealing the spirit, philosophy, and humor of our fighting men. It is indeed a contemporary record of their thoughts and experiences, and, as such, is an expression of their reaction to the world today.

Three thousand poems from almost every battle area came in

Book Reviews

response to the offer of $1,000 in prizes made by the publishers for the best entries. About 180 of these comprise the book. Winners include members of the Army, Navy, Merchant Marine, Air Corps, Marines, WACS, and WAVES, and it is interesting to note that the five main prizes were won by a member of the Merchant Marine, a corporal, a sergeant, a lieutenant, and a colonel in the order named.

Anthologies are necessarily arbitrary and limited, but this one contains much splendid material reflecting an exalted, eager spirit. Written in the present time of stress, the poems are typically American in that they portray no lust for war in the offering of life to preserve freedom. The eleven poems of John Ackerson, winner of first prize, deserve especial praise.

The committee of judges is well known: Mr. Henderson for his historical poems and editorial work for the Hearst publications, Mr. Kieran for his knowledge and judgment of poetry and sportswritings, and Mr. Rice for his poetry and sportswritings. Net profits on the sale of the book will be distributed equally between the U.S.O. and the Red Cross. G. J. C.

TORPEDO 8. By Ira Wolfert. Boston: Houghton-Mifflin. 127 pp. $2.

SWEDE LARSEN of United States Naval Aviation was a part of the torpedo squadron which was almost entirely wiped out by the Japs in a few minutes in the Battle of Midway. From that moment, vengeance was uppermost in Swede's mind, and he quietly and earnestly worked toward the fulfillment of the new motto of the rehabilitated Torpedo 8 which was changed from "Attack" to "Attack—and Vengeance." And this squadron made good in almost legendary fashion. The author has a charm and ease of expression that makes this not only one of the delightful books of the season but the most gripping and thrilling. T. K. V.

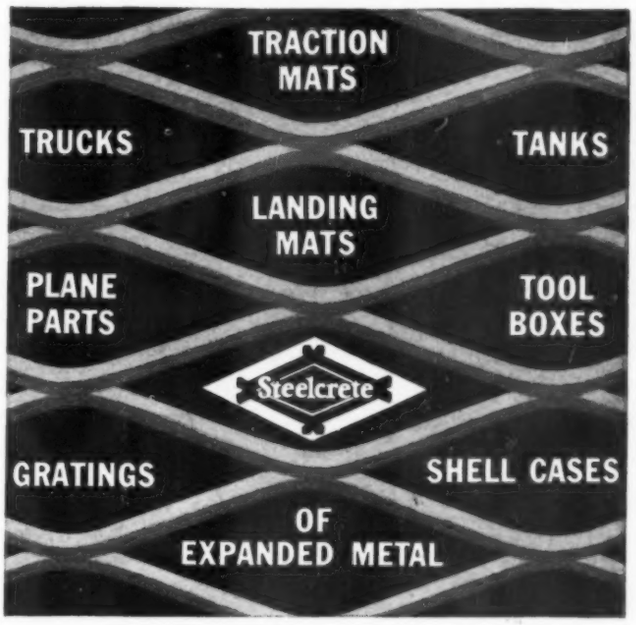
THE LUFTWAFFE. By Hauptmann Hermann. New York: G. P. Putnam's Sons. 300 pp. $3.

THE author is a former German flier who knows the inside of the German *Luftwaffe*, its organization, structure, the men who created it, and their deficiencies, their quarrels, successes, and failures. The Nazi fliers are pictured as a race apart, communistic in leaning, and believing fully in their invincibility and the power of the Führer. Nothing will stop them in their efforts except defeat or loss of confidence in themselves. If this happens, the *Luftwaffe* will collapse completely. The author's discourse on the future of aviation in general and Germany in particular is excellent. An extensive bibliography concludes the text. T. K. V.

ARMIES ON WHEELS. By S. L. A. Marshall. New York: William Morrow & Company. $2.50.

THIS is the second book in a series on the tactical results of the operation of mechanized armies in the present war. It treats of the second year of the war, a year in which it was possible to see more clearly some of the real achievements and weaknesses of the mechanized army.

In the second year of war many things showed up that had been foreseen by a few, but which many old-line army officers and the general public of the democracies were unwilling to listen to. Only the Germans seemed to realize that strategy lay in a superiority of weapons backed by armies of men trained in endurance. During the "Sitzkrieg" of 1939-1940, the British in Flanders had white bed sheets and professional entertainers and political spellbinders to protect the recruit from any severe discipline attempted by the officers. But all the time the Germans trained and trained and trained.



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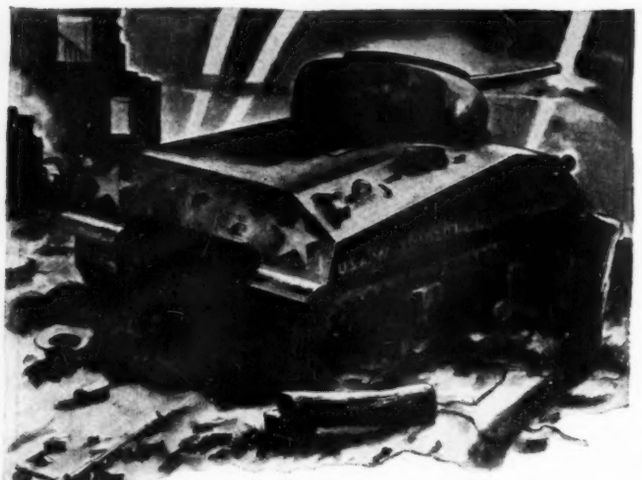

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Book Reviews

It took the defeats in France and Crete and Greece and the reverse of the army in Libya to make the democracies realize that tanks are merely machines that need fuel and oil and repair and cannot go far ahead of an army. They are the machine-age cavalry, requiring tough training for the operators and a hard-trained army to follow up the gains. Even the Germans, who appreciated tank tactics from the first, lost this point in the advance in Russia where they permitted small tank forces to get far ahead of the army only to be swallowed up by the enveloping Russian infantry. The author quotes from officers who have been through the Greek and African campaigns to prove that keeping the modern mechanized army moving is a grueling experience.

It is evident all through the book that the secret of mechanized warfare is found to be no secret at all. The tactics are the basic tactics of all warfare. Only the crescendo has increased a thousandfold, and the army that wins is the one that holds to the basic principles, increases the efficiency and the weight of its mechanism faster than its opponent, and, by hard, driving force, takes advantage of the gains won by its combat machines. G. S. B.

Rifleman Dodd. By C. S. Forester. Washington: *Infantry Journal*. 209 pp. $0.25.

FORMERLY published in England under the title "Death to the French," this story of a fighting man in the Peninsular Campaign with Wellington is fine reading. T. K. V.

Chemistry of Powder and Explosives, Vol. II. By Tenney L. Davis. New York: John Wiley & Sons, Inc. 191 pp. $3.

THE material in this work complements and completes the study of powder, explosives, and pyrotechnics so well begun in Volume I which contained chapters on properties of explosives, black powder, pyrotechnics, and aromatic nitro compounds. Volume II contains chapters on nitric esters, smokeless powder, dynamite and other high explosives, nitroamines and related substances, and primary explosives, detonators, and primers.

Dr. Davis' latest text is replete with historical sketches which add much interest to the subject for amateurs in the field of explosives and should remind professionals to realize anew all the pioneer work necessary to furnish them their modern explosive tools—which are too often taken for granted.

One of the great values of such a text is a complete index, and this work is exceptionally ample in this respect—it contains a 4-page index of names and a 27-page index of subjects. There is also an extensive bibliography which is conveniently placed throughout the book and correlated with the text by suitable footnotes.

The text covers many specific explosives which have been developed over the years but, of course, only a part of these are actually in day-by-day usage either commercially or in the military field. The book might have added value if there had been included some indication of the specific uses for which the various explosives have been applied, mentioning the properties which make them suitable for those uses. B. E. A.

Pick Out the Biggest. By Frank Morris. Boston: Houghton-Mifflin Company. 132 pp. $2.

MIKE MORAN, skipper of the Boise, ranks with John Paul Jones and Lord Nelson. The heroic acts of those who are in the thick of things are dramatically described, and the little-known heroes—the doctors, the engine-room gang, the chaplains—were also there in equally heroic rôles. It is the story of a great ship, wounded but able to keep going, with a skipper who will be legendary. The finest story of naval encounter to date. T. K. V.

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High up
On a ridge commanding the terrain
Sprawls a Signal Corps sergeant...
In his hand a field telephone
By his side an observer...
Eye and voice of the artillery

* * *

In the dusty distance
An enemy column moves onto a bridge...

* * *

Suddenly the voice speaks
And below at the other end of the wire
The thundering throats of hungry howitzers
Echo the command
With screaming steel and TNT

It's not a question
Of *whether* they'll hit the bridge
But *where*

* * *

As in a slow motion movie
The center span of the bridge
Mushrooms... up... *up*...
Then rumbles down into the gorge
Blocking the advance

The voice speaks again...
Gives the smoking howitzers
The new range
That will cut off the retreating column

* * *

From here on in
It's all over but the shooting
And the howitzer battery
Settles down to the grim business
Of annihilation

* * *

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Of field telephones for our armed forces
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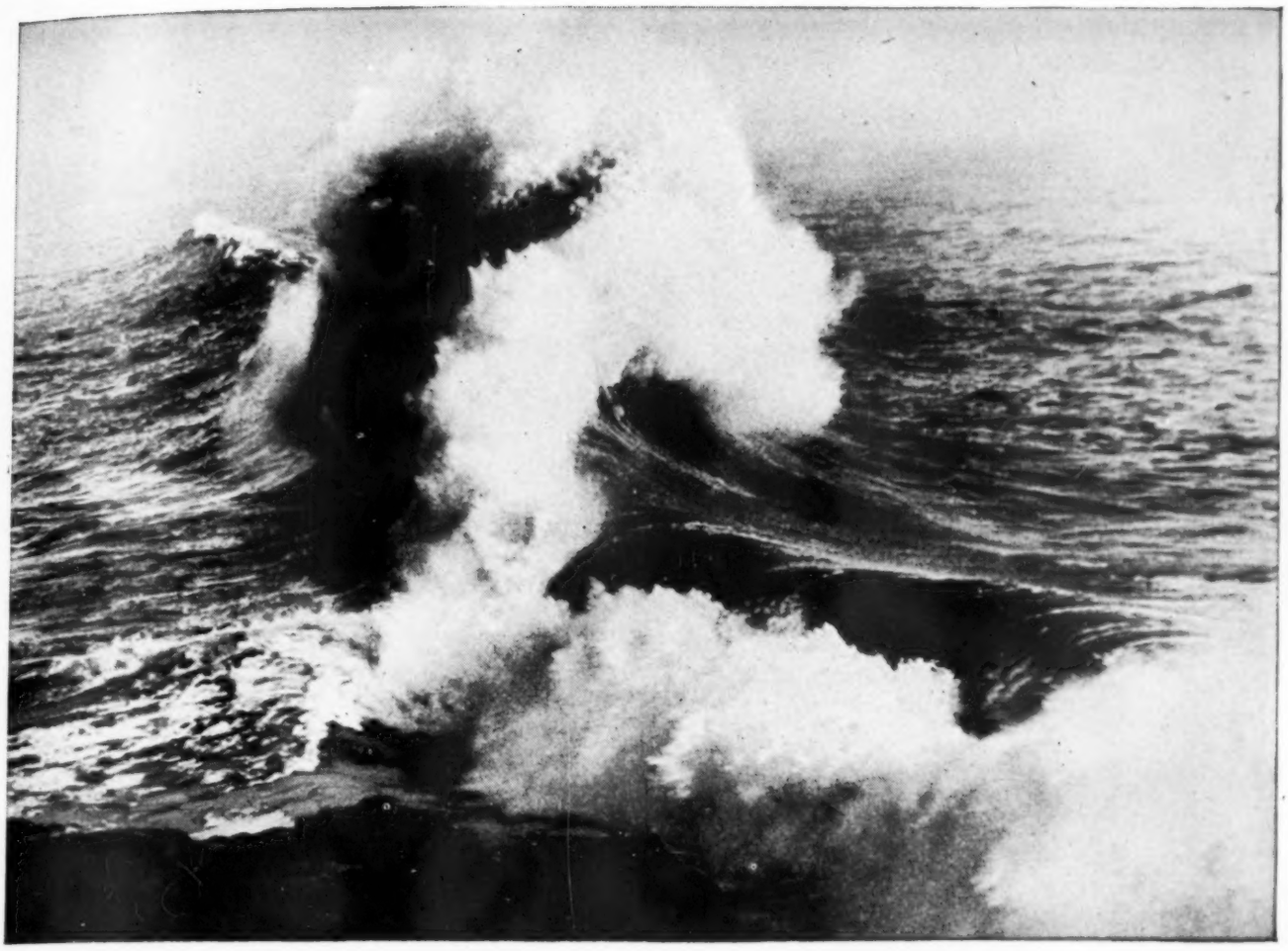

This is the reason they called the tube KLYSTRON*

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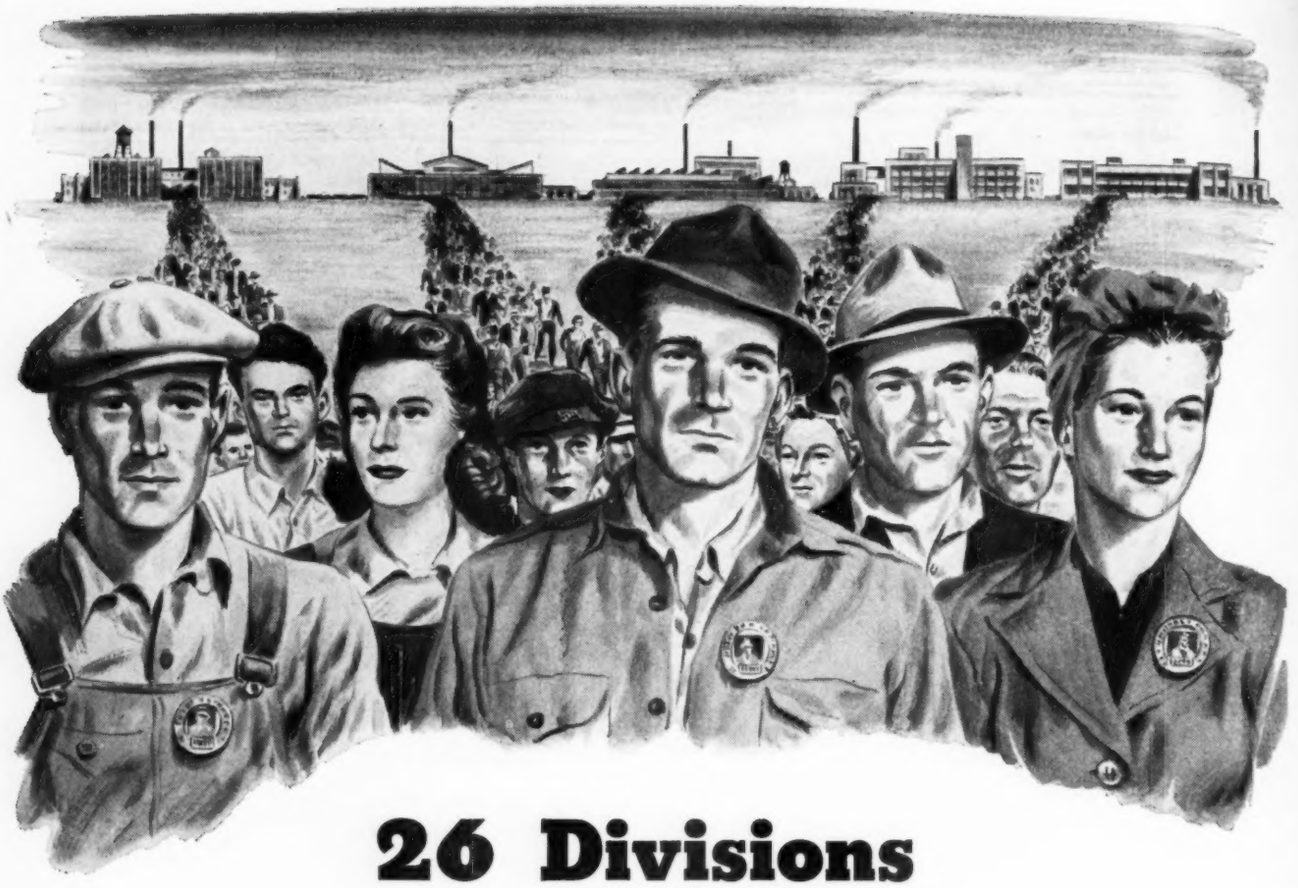

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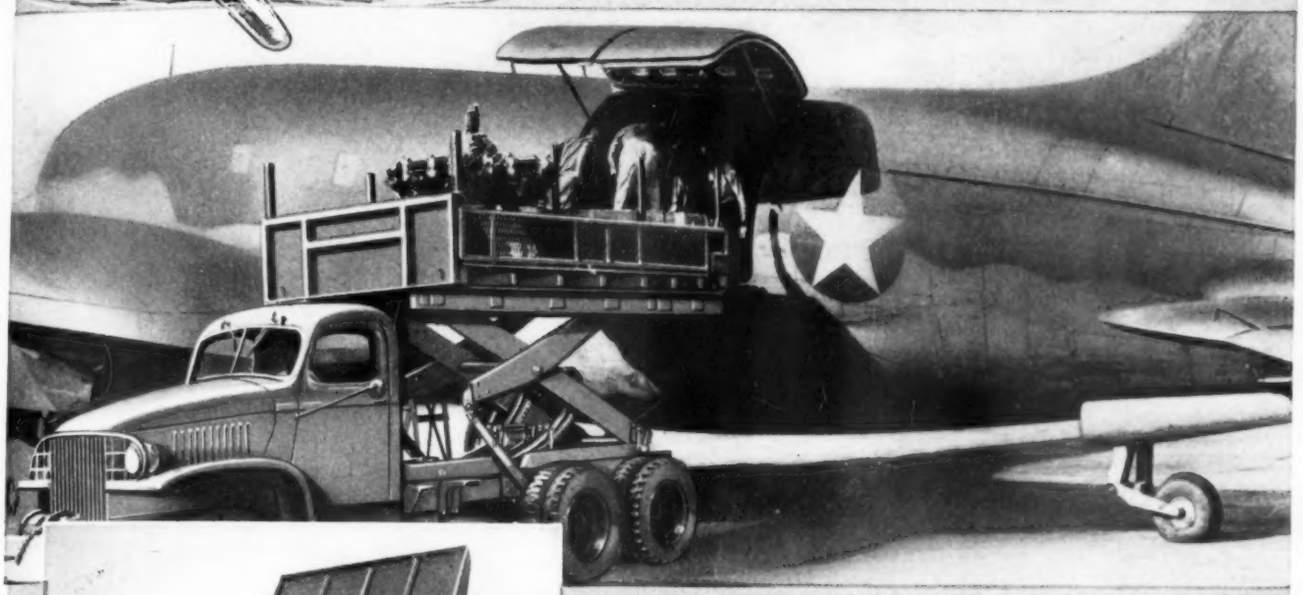

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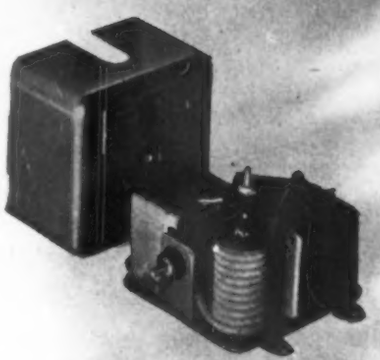

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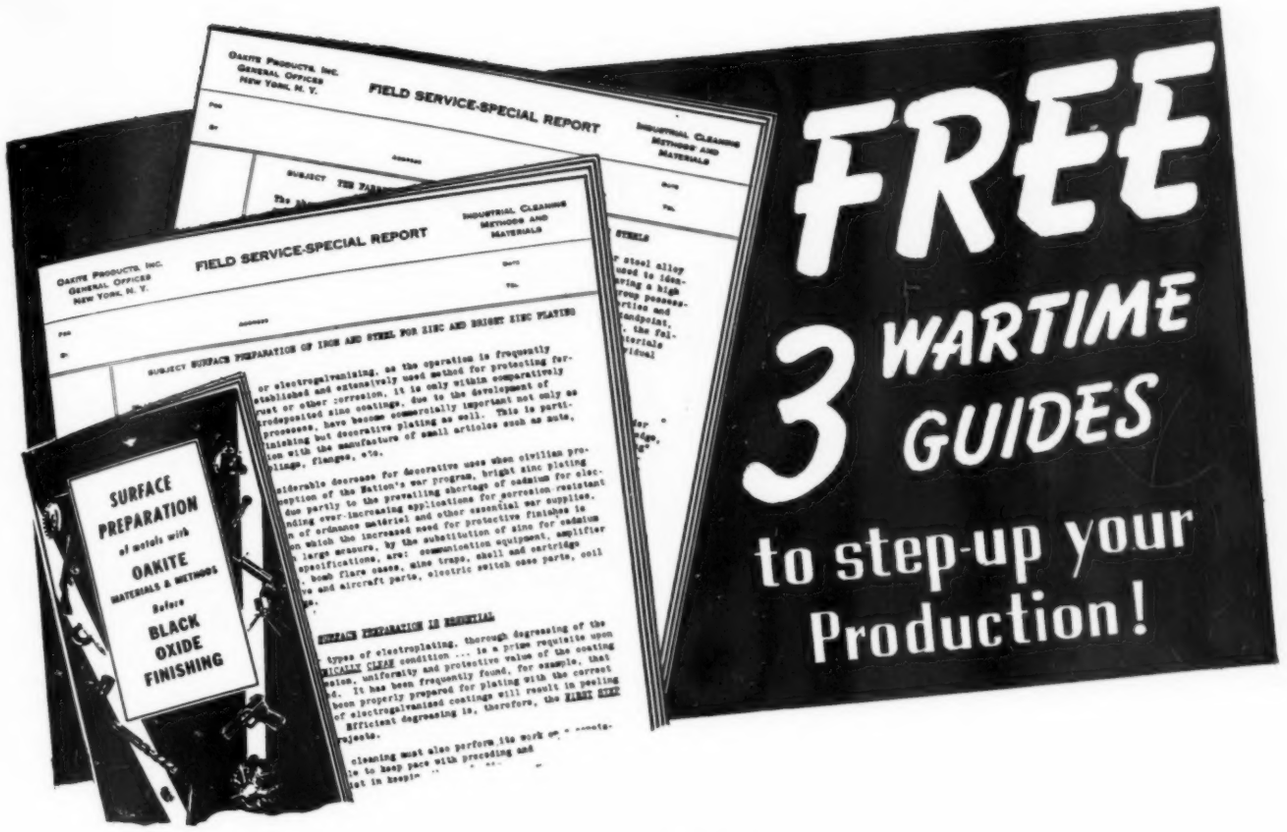
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Surface Preparation of Metals for Black Oxide Finishing

This 20-page manual is "must" reading for all executives responsible for black oxide finishing operations. Complete, concise, detailed, it explains how to obtain chemically clean surfaces that insure successful application of black oxide coatings. Gives specific directions and formulas. It is a helpful wartime guide for any plant now engaged in this work.

You are invited to write for any of these publications. Also, feel free to consult your nearby Oakite Technical Service Representative. Let him give you the benefit of his experience and knowledge on proper surface preparation before all finishing operations. Your inquiries invited, promptly answered.

OAKITE PRODUCTS, INC., 14F Thames St., NEW YORK 6, N. Y.

Technical Service Representatives in All Principal Cities of the United States and Canada

OAKITE MATERIALS...METHODS...SERVICE

CLEANING FOR EVERY CLEANING REQUIREMENT

METAL SPECIALTY

fulfilling exacting requirements for

INDUSTRY

in

PLASTIC MOLDING

and

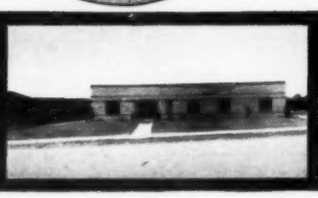
METAL WORKING

Drawing · Coining
Rolling · Forming
Stamping · Welding

Metal Specialty's plants are equipped to render you complete service in the fabrication of all Metal Parts, and in Plastic Injection Molding up through 18 ounces per shot. Along with 850-ton self-contained hydraulic presses for Metal Working, Metal Specialty has one of the four 18-36 ounce capacity injection presses for Custom Molding together with full complementary equipment.

Assembled Jobs · Pressed Metal to Order

ARMY E NAVY



The
METAL SPECIALTY *Co.*
MAIN OFFICE AND PLANT • ESTE AVENUE • CINCINNATI, OHIO

"GET THERE *FIRST* WITH THE MOST"

THAT'S war-winning strategy, but one that calls for the biggest material handling job the world has ever seen. Material handling starts with raw materials—it's vital to mill, factory, shipyard output—it's needed on railroads, docks, embarkation points, in Army and Navy bases—it's even a part of today's "front line" action because that's the real answer to "getting there first, with the most."

And when it comes to getting anywhere *first*, with the *most* in speed, power and range of use, the Moto-Crane stands out by itself. This completely mechanized unit rolls on 10 rubber tires, at truck speeds, with equal ease over highway or cross-country terrain. It's never tied to one spot; it gets around so rapidly, does jobs so quickly and well, it's just like having a crane available *anytime, anywhere.*

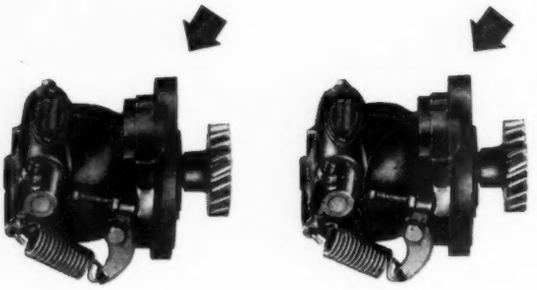
*It's not a Moto-Crane unless it's built by THEW-LORAIN

THE THEW SHOVEL COMPANY
LORAIN, OHIO

LORAIN

CRANES • SHOVELS • DRAGLINES • MOTO-CRANES

Two Peas in a Pod?



NO! *They're two different Governors built for two different purposes by the World's Largest Manufacturer of Governors*

● Both of the governors pictured above fit the same engine. But one is engineered to govern that engine in the operation of a pumping unit, where a tolerance of 8 to 10% in R.P.M. regulation gives satisfactory performance.

The other unit is engineered to govern that engine in the operation of critical electrical apparatus, where a variation of *only one cycle* can be permitted.

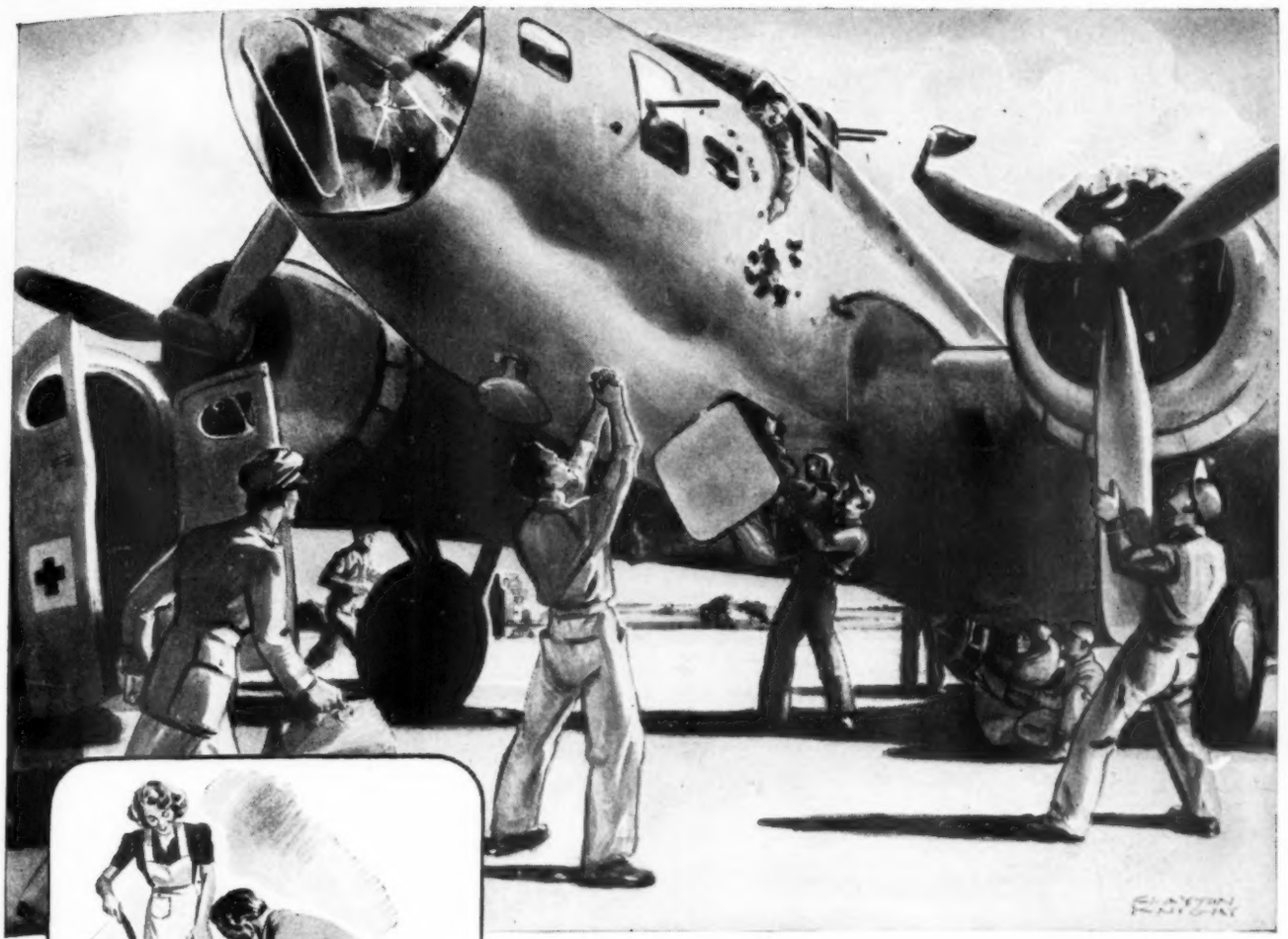
Each provides the most economical governing for the specific purpose, both from the standpoint of initial investment and efficient operation.

It is the *end use* to which an engine is to be put, not merely its make and model, that determines the right governor. Pierce has *engineered* over two thousand governor applications—each designed to do a special job on a specific piece of equipment. And Pierce has the *right* governor to do your *exact* job.

Tank, truck, combat vehicle, generator set, power shovel, marine, aviation equipment, and hundreds of other engines are *governed by Pierce*. In every case they meet, and frequently better, the closest specifications.

THE PIERCE GOVERNOR COMPANY, 1631 OHIO AVENUE, ANDERSON, INDIANA

Pierce Governors



THEY FLY WITH THEIR BOOTS ON—SAFER

Normal vibration can severely tax a plane. But imagine the strain vibration puts on the fastenings of big bombers which have been ripped and torn by enemy fire. That these huge craft, so punished, don't "shake apart" in mid-air is due in important measure to the stout, vibration-proof Boots Self-Locking Nuts they wear.

Boots Nuts, used on every type of U. S. aircraft, can't come loose no matter how severe the plane vibration. Lighter than any other nuts, Boots have greater re-usability too. In addition, they withstand the corrosive action of oil, water or chemicals—literally "outlast the plane." They simplify repairs and maintenance. And they meet the exacting specifications of all government aviation agencies.

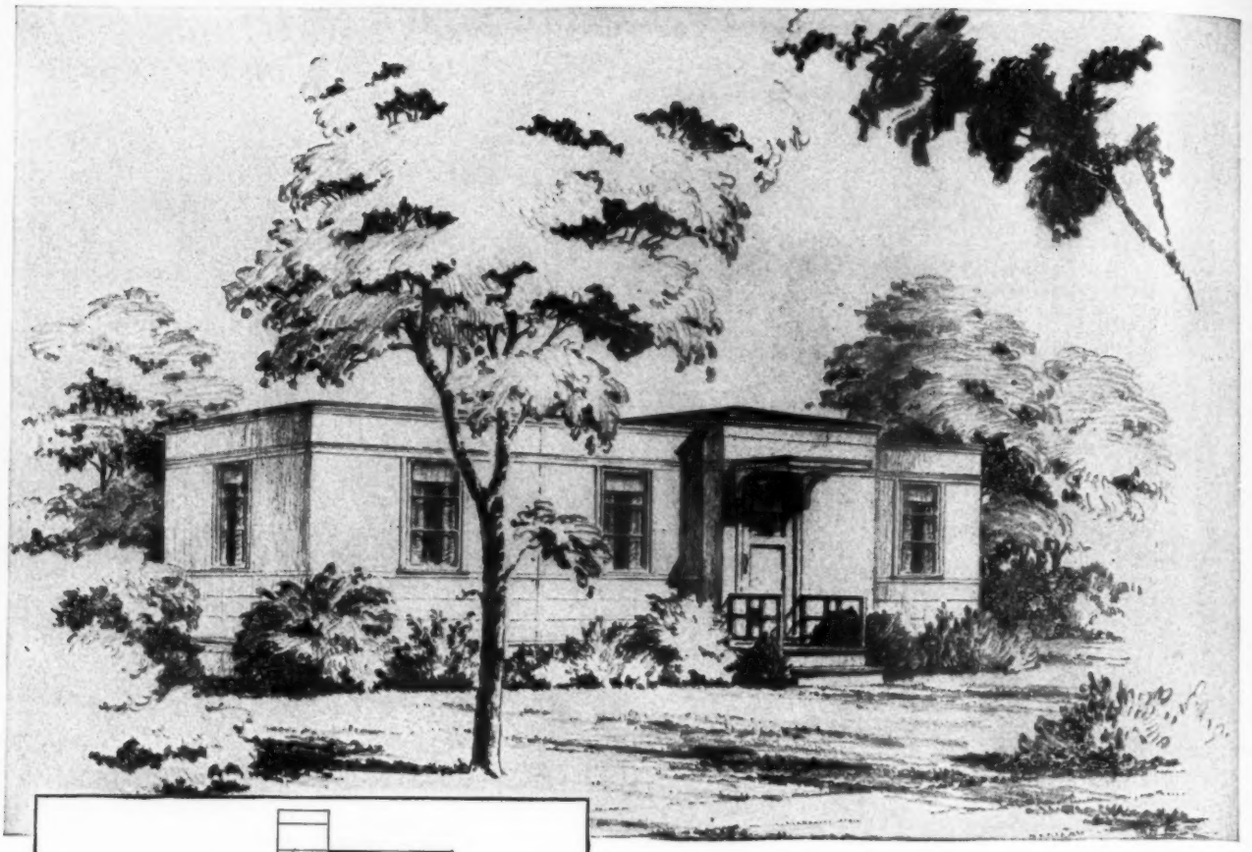
VIBRATION a Peace-Time Problem Too

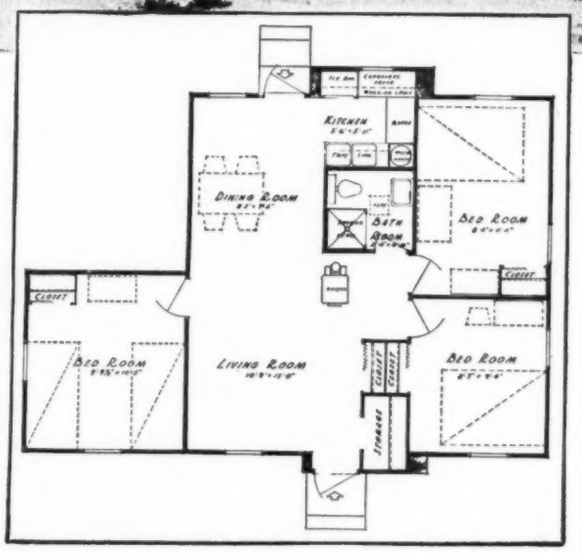
Very often costly repairs result from vibration-loosed connections in your vacuum cleaner, radio, electric refrigerator and other household appliances. Boots Self-Locking Nuts, used on these appliances, will eliminate repair bills caused by this type of mechanical failure. Boots Nuts can't come loose, even under the *severest* vibration. After victory insist on products protected with vibration-proof Boots Nuts. They will be your assurance of more economical and efficient service from the household appliances you purchase.

BOOTS

Self-Locking Nuts For Application In All Industries

BOOTS AIRCRAFT NUT CORPORATION ★ GENERAL OFFICES NEW CANAAN, CONNECTICUT





Emergency Housing
To Meet
Changing War Conditions

Low in cost, and conforming in every respect with the war housing requirements of the Federal Government, Palace portable dwelling units offer the ideal solution to the emergency housing problems that are constantly arising under changing war conditions.

Completely factory-built, factory-assembled, and factory-equipped —with plumbing, heating, and lighting equipment installed at the factory—Palace dwelling units are transported from factory to building site by motor truck, and are ready for occupancy practically upon arrival.

With one basic unit, as many as four variations in room arrangements can be supplied to meet the needs of each individual family. The units are provided either without bedrooms or with as many as four bedrooms, as desired—and with or without toilet, shower, and bath.

Possessing the same degree of mobility as a motor truck, the dwellings can be quickly moved from one locality to another as changing war conditions may require, or as need for additional housing in any particular community may develop.

Additional Information
Upon Request

Palace

CORPORATION
Flint, Michigan

TRAINING LESSON No. 2

For New 'Dozer Operators

How To Increase Yardage . . . Reduce Costs with LaPLANT-CHOATE 'DOZERS

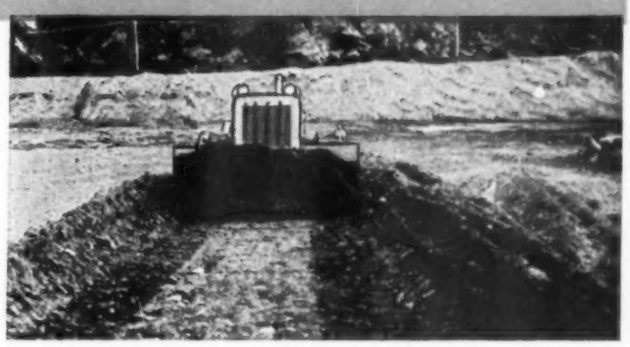
HOW TO get more output from present machines and untrained manpower is coming to be more of a serious problem every day. Especially in the fields of earth moving and land clearing, where considerable skill and experience are required for efficient operation of 'dozer and scraper equipment. In an effort to simplify these problems, LaPlant-Choate is using this current series of advertisements to bring you practical "job hints" gained through years of close contact with thousands of successful users throughout the world. Much of this information is not new, but in sharing the "know-how" of LaPlant-Choate engineers, it is our hope that somewhere along the line, we may give you an idea that will prove helpful — in speeding up an important job, or in training new operators. There are literally hundreds of jobs that can be done faster, easier, better with one man and a LaPlant-Choate 'dozer — and it is the purpose of these messages to explain how to get the best results.

Average 'Dozer "Yardage Table"

Showing estimated cubic yards (bank measure) moved per hour with various size tractors on various length hauls.

Tractor Size	Gear Group	Average Haul in Feet					
		50′	100′	150′	200′	250′	300′
D-8	Standard	124	92	59	48	39	31
D-7	Standard	110	73	52	47	39	32
D-6	Standard	90	58	44	38	32	28

NOTE: *Based on good earth or loam on level hauls, using the following pay loads per trip: 2.3 cu. yds. for the D-8 tractor; 1.9 cu. yds. for the D-7 and 1.5 cu. yds. for the D-6. Note efficiency of the D-7 and D-6 on longer hauls, due to high speed reverse gears. Average fixed time for shifting gears at each end of run is approximately 0.3 minutes.*



Following the same path on successive trips keeps more dirt ahead of the blade, thus increasing loads.

6 Ways to Increase 'Dozer Production

1. Drifting dirt down hill will increase yardage (uphill will decrease it). Controlling factors are: grade, travel speed and kind of material.
2. Quantities can also be increased from 30 to 50% when backfilling or drifting material short distances into excavations.
3. When digging or drifting loose material, extra yardage sometimes can be gained by working two 'dozers side by side (if you have good operators.) This gives the effect of one long blade with less spillage.
4. When working downhill or in a trench, try moving one blade full of material into the start of the haul. Then back up and push in another load before you start to the dump — this doubling the amount of material you move each trip.
5. When moving forward with a load, keep your blade in a position to make a light cut — thus replacing the material lost around the ends and leaving a smooth surface for following trips.
6. On longer hauls, follow the same path on successive trips, so that dirt spilling out from the ends of the blade will form a windrow on both sides of the 'dozer. This will keep more dirt ahead of your blade and increase your loads.

WHEN YOU NEED HELP, CALL YOUR *LaPlant-Choate-* *"Caterpillar"* DISTRIBUTOR FOR PARTS AND EXPERIENCED SERVICE

ARMY E NAVY

LaPLANT-CHOATE MANUFACTURING CO. Inc.

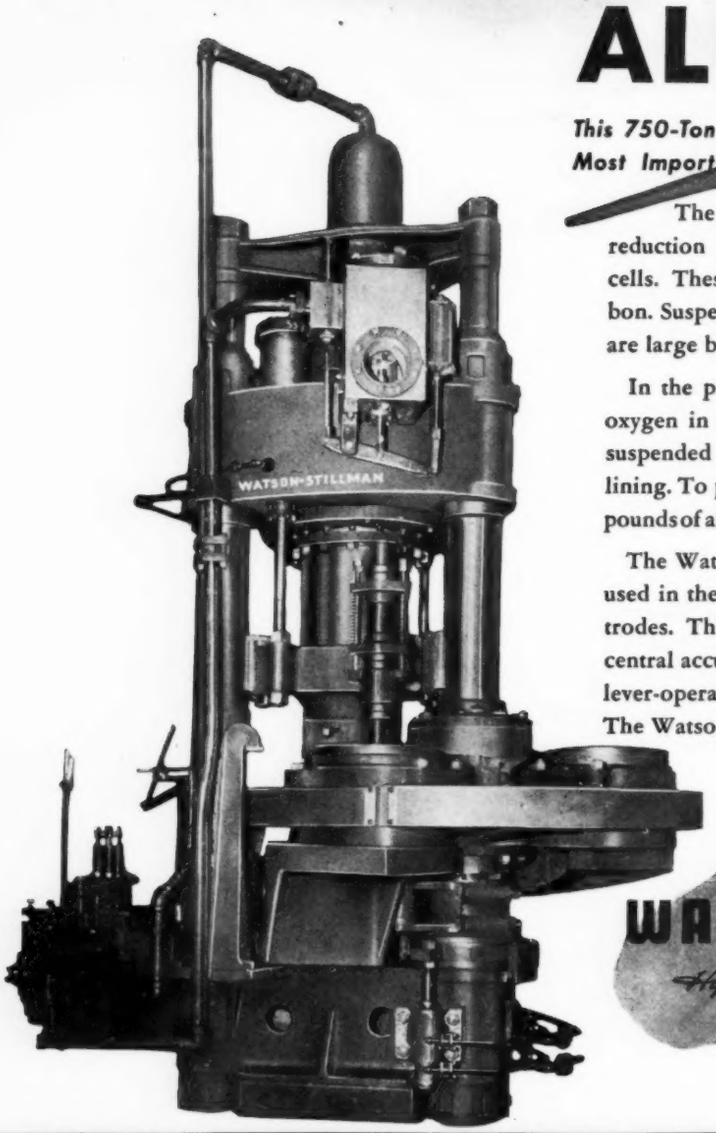
CEDAR RAPIDS, IOWA, U.S.A. - CABLE: "LAPCHOATE"

WORLD-FAMOUS TOOLS FOR EARTH-MOVING, LAND-CLEARING AND SNOW REMOVAL. BULLDOZERS, TRAILBUILDERS, "CARRIMOR" SCRAPERS, RIPPERS, TAMPING ROLLERS, TREEDOZERS, BRUSH AND ROOT CUTTERS, BRUSH RAKES, STINGER BLADES, STUMP SPLITTERS, ETC. (HYDRAULIC OR CABLE CONTROLLED)

CARBON

. . . its part in producing

ALUMINUM



This 750-Ton Watson-Stillman Press Performs One of the Most Important Jobs in the Aluminum Reduction Plant.

The last step in the production of aluminum in the reduction plant is accomplished in large electrolytic cells. These cells are built of steel and lined with carbon. Suspended inside the cell on a bus-bar arrangement are large blocks of carbon, or electrodes.

In the process of separating the aluminum from the oxygen in the alumina, the current enters through the suspended electrodes and passes out through the carbon lining. To produce one pound of aluminum requires two pounds of alumina and three-quarters of a pound of carbon.

The Watson-Stillman 750-Ton Rotary Table Press is used in these reduction plants to mold the carbon electrodes. This machine is activated by pressure from a central accumulator station. The main control valves are lever-operated. The machine stands 18 ft. 6 in. high. The Watson-Stillman Co., Roselle, N. J.

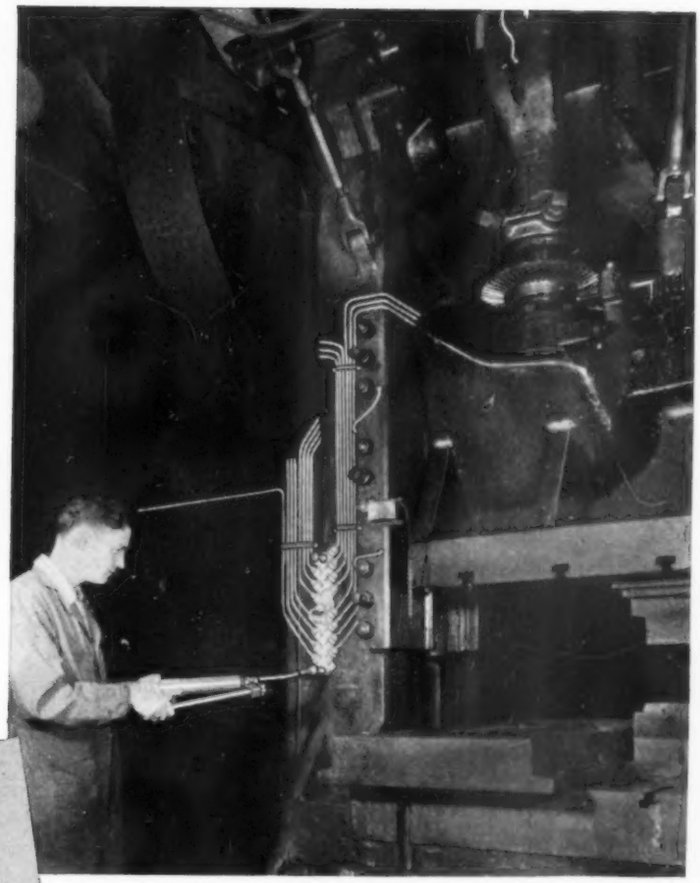
WATSON-STILLMAN

Hydraulic Equipment, Valves, Forged Steel Fittings

For Victory ★★★ Let's all be Scrappers

SCORES OF WAR PLANTS NOW

Cut hours off lubrication Time!



New Alemite Progressive System Ends "Time Out" For Lubrication . . . Serves all Bearings From One Location With One "Shot" Without Stopping Production

Here's how it works . . .

- Delivers a predetermined quantity of grease to each bearing, no matter how remote, while machinery is in motion.
- Signals when lubrication is complete—saves lubricants and time. Eliminates guesswork.
- An example of time-saving: One war plant cut lubrication time on big lathes from 18 minutes per shift on each machine to 1 minute every 6 days.

WITH American industry striving for new production records, men and machines are taxed to the limits of endurance. Thus, it becomes vitally important that every man-hour and machine-hour show maximum results in terms of finished products.

The new Alemite Progressive Lubrication System contributes to this end. It is accurate and dependable and fool-proof . . . actually pays for itself in a remarkably short time. Write today for complete details of this time-saving, money-saving lubrication method.

Alemite 7700 Series

Air-Operated Barrel Pumps

- A complete range of heavy duty pumps available for high or low pressures. These pumps handle light or heavy consistency greases direct from original drums, eliminating contamination and saving grease. Ample capacity to serve several outlets.

Ask Anyone in Industry!

ALEMITE

REG. U.S. PAT. OFF.

Industrial LUBRICATION

1802 Diversey Parkway, Chicago, Illinois • Belleville, Ontario

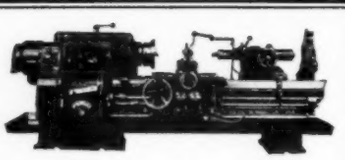
Another Product of STEWART WARNER

Little things can ~~ruin~~ *make* a job

Bullets from a machine gun or teeth on a lathe gear must be true to the mark — or else.

On battle field or factory floor we can't afford to miss. Should a precision piece of work being turned on a lathe be spoiled the reject means loss of vital metal, doing the job over and most important of all, delay in delivering battle weapons that might have saved some soldier's life.

During the production of a single Axelson Lathe, its parts receive a multitude of tests and inspections. Spacing of gear teeth is checked by the dual-dialed Swiss tester shown above. Tension and compression capacities of the metal are tested in a machine capable of developing up to 100,000 pounds; degrees of hardness are determined by the Rockwell tester and by the Brinell method; grain structures are examined microscopically. Headstock alignments are tested to .0001", while cross-slide alignment is checked with the standard face plate furnished with each lathe. Skilled inspectors, provided with every needed precision measuring device, check every essential dimension.



Axelson Lathes afford a wide range of operating speeds and feeds necessary for fast production. Manufactured in 14, 16, 18, 20, 25 and 32 inch sizes, in varying lengths.

Inflexible Axelson standards, fixed over twenty-five years of machine-tool manufacture, are your guarantee that the little things in your precision work will be perfect. That guarantee is yours today and it will go with every Axelson Lathe that you buy — in the future.

AXELSON MANUFACTURING COMPANY
6160 South Boyle Ave., Los Angeles, Calif.
(P. O. Box 98, Vernon Station)
50 Church Street, New York City, N. Y.
3844 Walsh Street, St. Louis, Missouri

Buy More War Bonds For Victory

AXELSON LATHES

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

ARMY (E) NAVY

DEPENDABLE FOR OVER A QUARTER CENTURY

PORTAGRAPH PHOTO-COPY SPEEDS ENGINEERING OPERATIONS

SHIPYARDS

AIRCRAFT COMPANIES

TOOL MANUFACTURERS

AND MANY OTHER WAR PRODUCTION PLANTS

FOR YOUR COPY
CLIP AND MAIL COUPON TODAY

● With PORTAGRAPH photo copies, engineering operations can be speeded up—from the designer's "rough" sketch to the production of working copies.

Where it used to take a draftsman many *days* to produce necessary manual tracings and copies, Portagraph reduces the time to mere *hours* or *minutes* —and results in a copy whose sharpness and clarity often surpasses the original. Portagraph copies from pencil drawings are clearer than the original and resemble ink tracings.

What's more—you are not confined to a single type of paper in using Portagraph. In addition to the many grades of Portagraph contact paper, sensitized tracing vellum and sensitized tracing cloth normally used in engineering processes, Portagraph also offers a variety of products useful in other copying applications. These include a double weight card stock, duplex paper sensitized on both sides, orthochromatic contact film, map cloth, etc.

Portagraph reproduction versatility in war industries is forcibly told by the engineers themselves in a series of Gould Reports. A copy of these reports is yours for the asking. No obligation whatsoever. Send for it today.

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REMINGTON RAND INC.
BUFFALO 5, NEW YORK

GOULD REPORTS

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Please forward, without obligation, the H. P. Gould Report on how to reduce costly tracing, drawing and copying in engineering departments.

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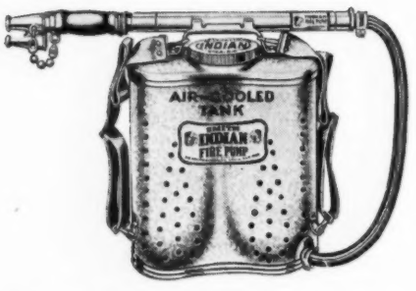
INDIAN
FIRE PUMPS
will put out fires
set by enemy
raiders!
Tells How Lone Jap Tried to Fire Oregon Forest
PORT ORFORD, Ore.—(U.P.)—Witnesses were permitted today to describe a previously undisclosed attempt by a Japanese plane to start a raging fire in the Oregon forests.
The western defense command released the stories of the witnesses after it was announced at Washington that three enemy attacks have been made on the Pacific northwest. Two of the attacks had been disclosed previously.
The third occurred early on the morning of Sept. 29, 1942, when a one plane, presumably catapulted from a Japanese submarine, flew over the lonely Grassy Knob Service lookout station 10 miles of here. The plane dropped into the dry bed of a 2½ miles below
pretty soon we heard it again, this time coming back toward the ocean," Zumwalt
engine



Here is the outfit which will make short work of forest, grass, and brush FIRES!

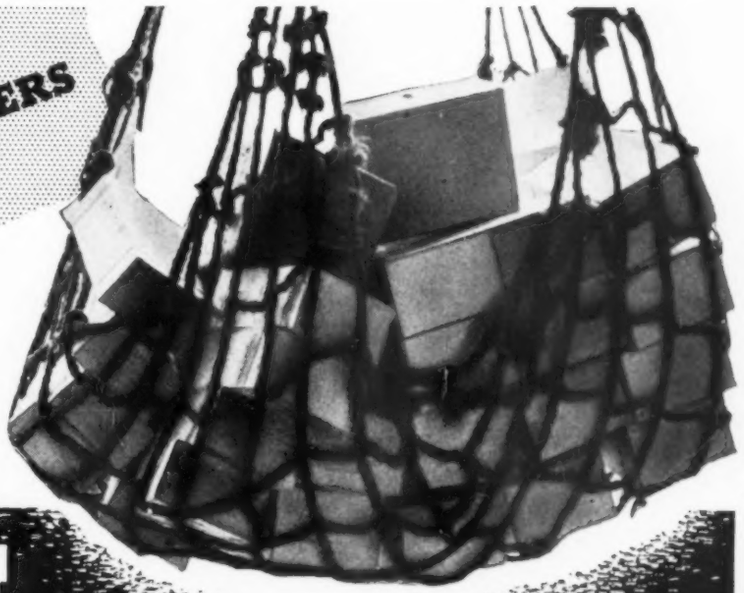
INDIAN FIRE PUMPS have dozens of uses in and about all Army posts. They are just the thing for fires on artillery and rifle ranges, fires in mess halls, tents, and storage depots. Prompt use of INDIANS will save vital forest areas from destruction by fire resulting from accident, sabotage, or enemy action.

INDIANS use only clear water—no chemicals. Any water supply serves for quick filling. Pump throws 30- to 50-ft. pressure stream. Thousands are giving highly satisfactory service. *Send for catalog giving full details, prices, and testimonials.* WRITE TODAY!

D. B. SMITH & CO., 422 Main St., UTICA, N.Y.

Pacific Coast Branch
HERCULES EQUIPMENT & RUBBER CO.
435 Brannan St. San Francisco, Calif.

SEAL
WATERPROOF CONTAINERS
with



SOLSEAL
WATERPROOF TAPE
for OVERSEAS SHIPMENTS

OF INTEREST TO EVERY EXPORT SHIPPER is this newly perfected water-resistant tape. Its objective—to seal the new waterproof or moisture-resistant containers intended to carry materials for overseas shipments.

SOLSEAL Tape is available in 30/30/30 and 60/30/30. Also available string-filled.

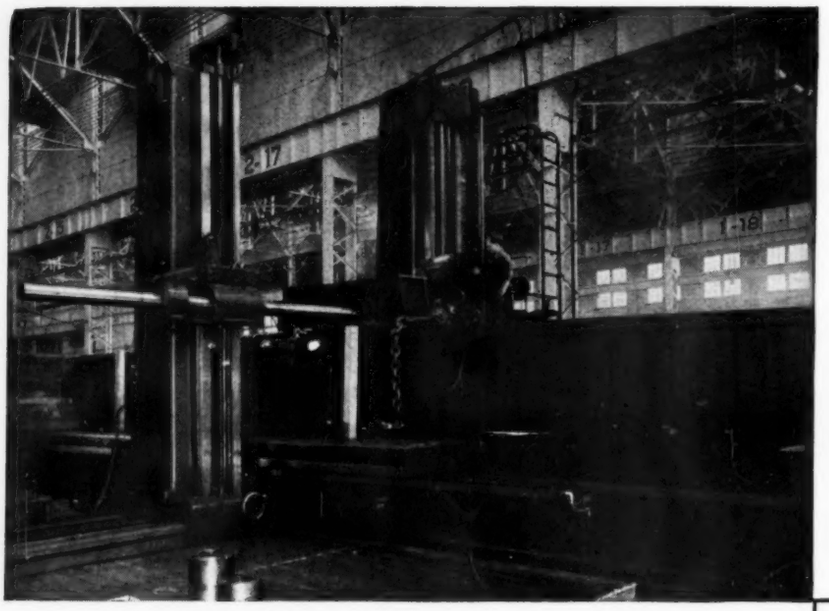
Multiple tests have proven that the tape adheres to the container *for over eight weeks after immersion!* Under conditions of high humidity, rain and actual immersion this tape answers a real need. Write for *free sample coil* with solvent for testing purposes. Specify type of SOLSEAL sample desired.

SOLSEAL Tape may be obtained from the following companies:

Atlantic Gummed Paper Corp., Brooklyn, N.Y.
The Brown-Bridge Mills, Inc., Troy, Ohio
Central Paper Company, Menasha, Wis.
Edgewater Paper Company, Menasha, Wis.
McLaurin-Jones Co., Brookfield, Mass.
Mid-States Gummed Paper Co., Chicago, Ill.
Rexford Paper Co., Milwaukee, Wis.
Thomas Stationery Mfg. Co., Springfield, Ohio

McLAURIN-JONES CO.
BROOKFIELD, MASS. • OFFICES: NEW YORK • CHICAGO • LOS ANGELES

Official U. S. Marine Corps Photo



(*Above*) *Boring 10⅛" Dia. Hole in Gear Case of Boom*

How To Machine Large Parts . . . *in fewer settings!*

10 Operations Completed in 3 Settings of Shovel Boom . . . Wgt. 32,000 Lbs.

(*Above*) *32,000-lb. Welded Steel Boom*

Manufacturers of heavy cumbersome equipment can use the versatility of G & L machines to good advantage. The variety of available operations such as boring, drilling, milling, facing *and tapping* often makes it possible to perform numerous operations in one setting. Lost time in moving the part to other machines and resultant inaccuracies are eliminated.

In this installation a 48-ft. long welded steel shovel boom is machined completely in only three settings. Ten operations, including milling, boring, facing and drilling, are performed.

Since the machine table is 25 feet shorter than the shovel boom, great care is exercised in setting it up for machining. All strains of overhang are shimmed out, while ends are supported by jacks. The job is then bolted to the machine table and jacks removed.

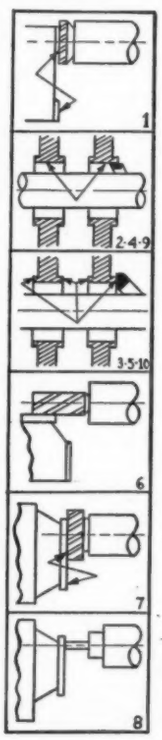
G & L machines are being used for unlimited machining operations on both small and large parts in many industries. With G & L attachments and accessories there is practically no combination of operations that cannot be performed with great speed and economy. Feeds and speed ranges cover all metals, and practically any cutting requirements.

G & L engineers will be glad to make recommendations for faster machining of your work on present or new G & L equipment. They are at your service without obligation.

Versatility:

FOR PROPER MACHINING SEQUENCE AND FEWER SETTINGS

Proper machining sequence is available through ample feeds and speeds and versatility of G & L machines. The ten operations on the shovel boom are shown below:



FIRST SETTING:

OPERATION 1—Mill eight pads for set-up purposes on Operation No. 7.

OPERATION 2—Bore two 10⅛" diameter bores in gear case. (3 cuts, rough, semi, and finish.)

OPERATION 3—Face and back face both sides of bores.

OPERATION 4—Bore two 8.377" holes for intermediate gear shaft.

OPERATION 5—Face and back face both sides of bores.

OPERATION 6—Mill strip on top face of gear case for alignment purposes in Operation No. 7.

SECOND SETTING:

BOOM ROLLED OVER 90° AND PARALLELS PLACED UNDER PADS MILLED IN FIRST OPERATION

OPERATION 7—Mill top of gear case.

OPERATION 8—Drill twenty-two 1¹⁵⁄₁₆" holes in gear case cover flange.

THIRD SETTING:

BOOM TURNED AT ANGLE OF 39° 14' 17" TO CENTER LINE OF SPINDLE

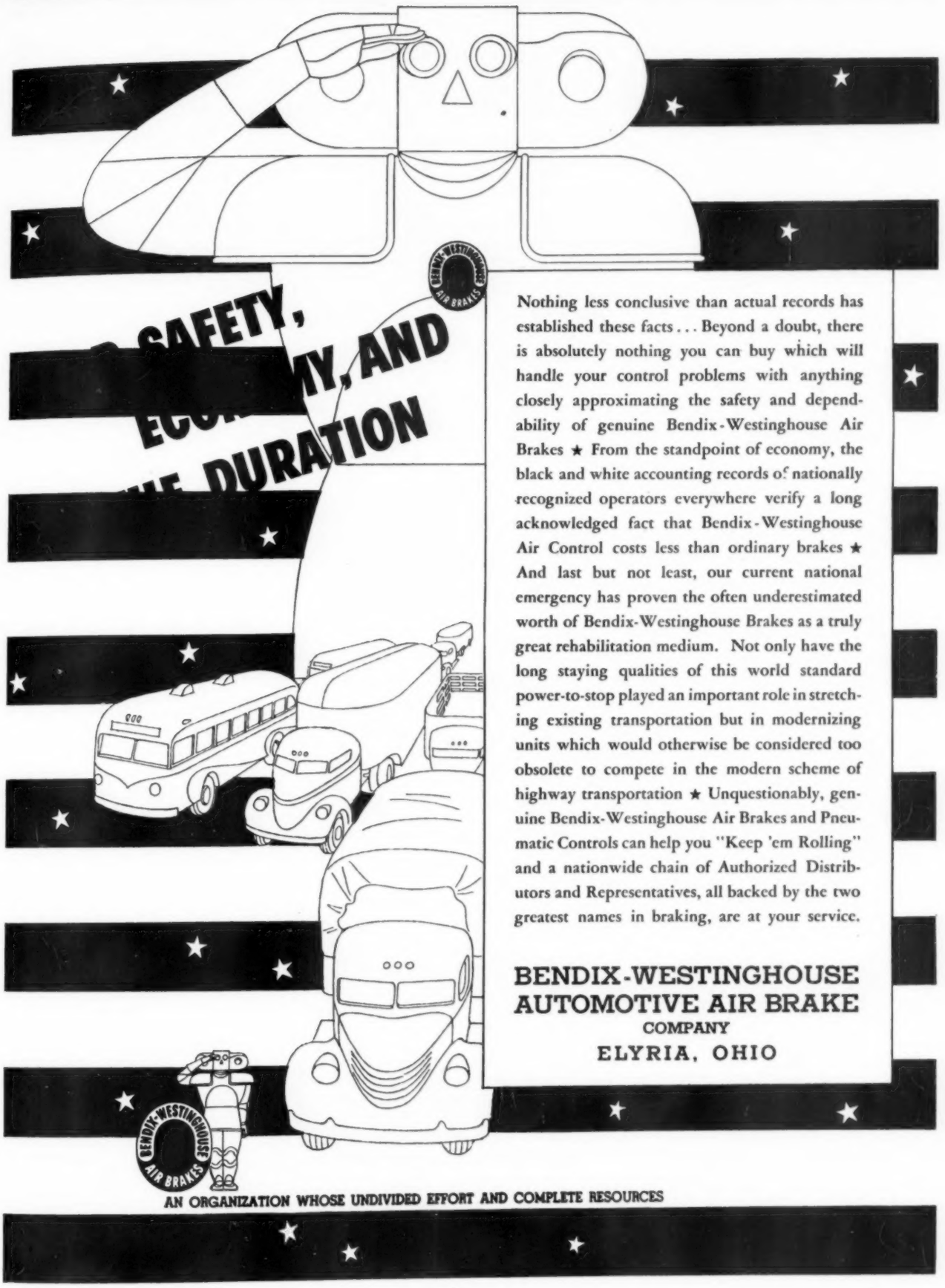
OPERATION 9—Bore two 5½" holes for worm drive.

OPERATION 10—Face and back face both sides of bores.

GIDDINGS & LEWIS MACHINE TOOL COMPANY

138 DOTY ST., FOND DU LAC, WISCONSIN

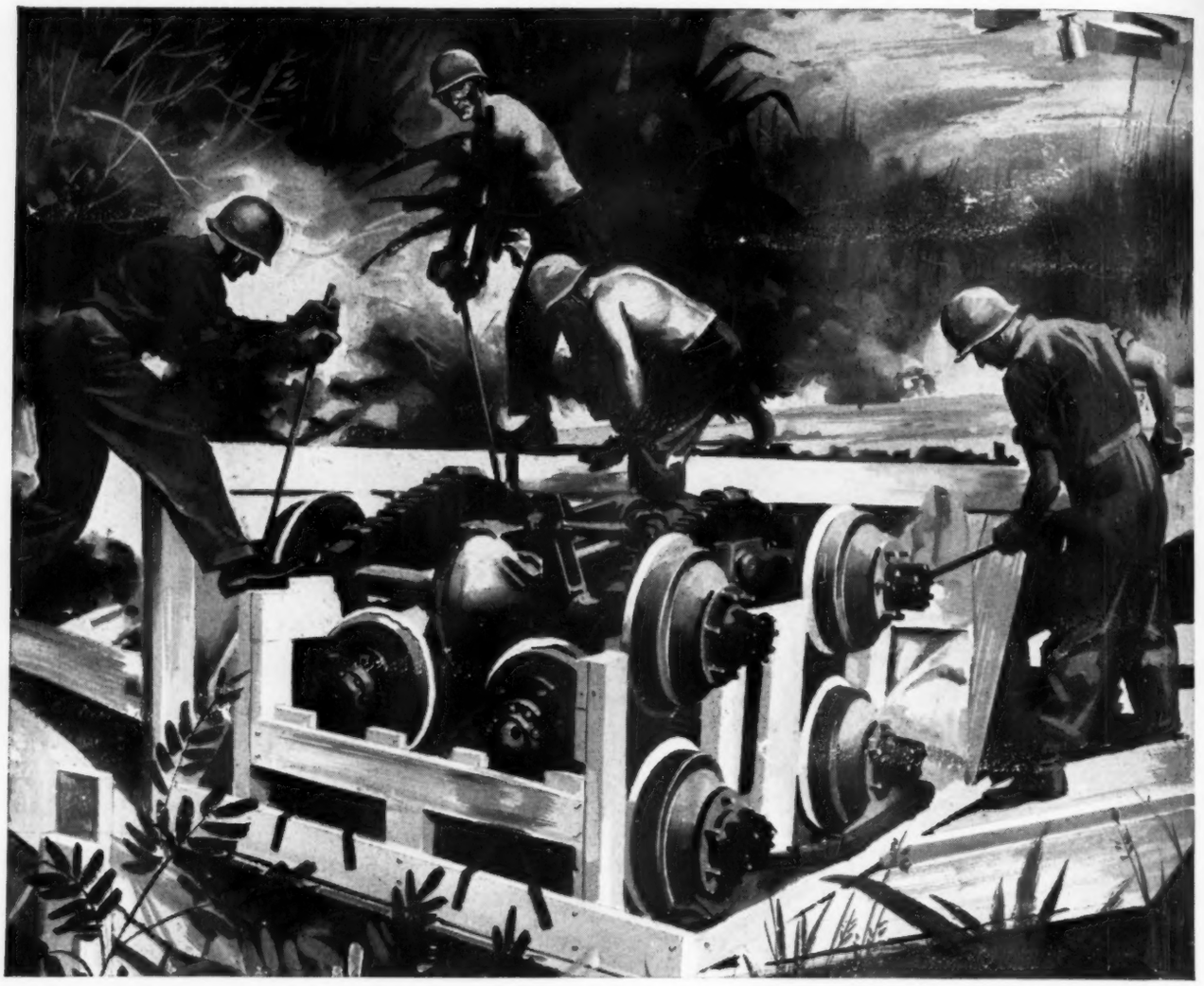
Free Data *Information covering the complete line of G & L machines and time-saving attachments and accessories is included in this catalog. Write for your copy. Ask for Catalog No. 3.*



Nothing less conclusive than actual records has established these facts . . . Beyond a doubt, there is absolutely nothing you can buy which will handle your control problems with anything closely approximating the safety and dependability of genuine Bendix-Westinghouse Air Brakes ★ From the standpoint of economy, the black and white accounting records of nationally recognized operators everywhere verify a long acknowledged fact that Bendix-Westinghouse Air Control costs less than ordinary brakes ★ And last but not least, our current national emergency has proven the often underestimated worth of Bendix-Westinghouse Brakes as a truly great rehabilitation medium. Not only have the long staying qualities of this world standard power-to-stop played an important role in stretching existing transportation but in modernizing units which would otherwise be considered too obsolete to compete in the modern scheme of highway transportation ★ Unquestionably, genuine Bendix-Westinghouse Air Brakes and Pneumatic Controls can help you "Keep 'em Rolling" and a nationwide chain of Authorized Distributors and Representatives, all backed by the two greatest names in braking, are at your service.

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY
ELYRIA, OHIO

AN ORGANIZATION WHOSE UNDIVIDED EFFORT AND COMPLETE RESOURCES



TEAMWORK!

KEEPS TIMKEN AXLES MOVING TO THE FIGHTING FRONTS

At an island base somewhere in the South Pacific, these sturdy, dependable Timken Axles are being uncrated for replacement on American-made military motor vehicles. They are also being shipped to strategic points overseas where full-scale American production lines have been set up for assembling military motor vehicles.

On the home front, thousands of these same axles are being delivered to military vehicle manufacturers as rapidly as required.

Timken acquired the fundamentals of team play years ago, working with the leading motor vehicle manufacturers of America. More than 15 years ago, we teamed with the Army Ordnance Department to aid in motorizing and mechanizing the U. S. Army.

In all these years we have never failed to realize the first fundamental of teamwork—if one member of the team fails, it may cost the others a well-earned victory.

ARMY E NAVY
For Production
"Well Done"

TIMKEN AXLES

THE TIMKEN-DETROIT AXLE CO., *Main Office* DETROIT, MICHIGAN
WISCONSIN AXLE DIVISION, OSHKOSH, WISCONSIN

The sun never sets on the fighting jeep . . .

COURTESY WILLYS-OVERLAND MOTORS INC.

nor on **N-A-X** high tensile steel

DUCTILITY — ITS INDEFINITELY FINER GRAIN MAKES ALL THE DIFFERENCE — STRENGTH

Battle-proved on a score of fighting fronts, the Willys-built Jeep has earned a world-wide reputation for ruggedness, for built-in stamina, and for ability to take punishment under all sorts of conditions as to both temperature and terrain.

N-A-X HIGH TENSILE Steel is used in the construction of the Willys-built Jeep, and the unusual qualities of this steel find expression in the field performance of this most versatile of all combat vehicles.

N-A-X HIGH TENSILE is used in countless other types of fighting equipment, too, wherever strength, ruggedness, and high resistance to impact and fatigue are required. And on every battle front, in every theater of war, N-A-X HIGH TENSILE is daily demonstrating its excellent qualities.

Write today for your copy of a new booklet describing fully the properties and characteristics of N-A-X HIGH TENSILE and the N-A-X 9100 Series Alloy Steel.

GREAT LAKES STEEL CORPORATION
Detroit, Michigan
Sales Offices in Principal Cities

NATIONAL STEEL CORPORATION

Division of
NATIONAL STEEL CORPORATION
Executive Offices · Pittsburgh, Pa.

ALL 3 NOW
FIGHT WIN PLAN
to be ready WHEN THE SHOOTING STOPS*

This message is especially for INDUSTRIAL EXECUTIVES who are very busy producing war goods.

★ WE OFFER ★
TO RESPONSIBLE PEOPLE

INGENUITY

along with extensive facilities for bettering anything made from metal... large or small Parts... Complete Assemblies... experimental pieces or mass production.

AFTER VICTORY

The genius that America contributes in the all-out Fight to Win can also (and at the same time) do a third thing: Plan, in a practical way, for the peace.

In our own small way we at Spriesch have been planning to help other manufacturers, After Victory. The Spriesch organization is not just another miracle war plant. Long before Pearl Harbor, we were said to be performing miracles, in the manufacture of bomb-releasing mechanisms for fighting aircraft.

Right NOW we seek contact with those to whom "All 3 at the same time" is feasible. They will like to consider using part or all of our facilities for "bettering anything made from metal" such as:

Combined engineering-dies-tools-parts or complete assemblies service...Designing and making Special Machines... Initial, periodic or continuous recommendation for product improvement or production procedure... Help on What to make After Victory. Distance will present no insurmountable barriers to rendering these services.

Industrial Executives are invited to write NOW (on business letterhead please) for our newly printed booklet, "After the Shooting Stops" and for our 36-page plastic bound brochure titled "Ingenuity." The latter illustrates and describes our extensive facilities. Frankly, we think you'll be pleased.

Joseph J. Cheney, President.

Established 1923

Spriesch TOOL & MANUFACTURING CO., Inc.

16 HOWARD STREET • • BUFFALO 6, NEW YORK

**This is a collection of articles inspired by the activities of the Spriesch organization which appeared recently in The Monetary Times, Canada, in the magazine Steel and in Printers' Ink.*

AD No. 20

TOLEDO BLADES—1943

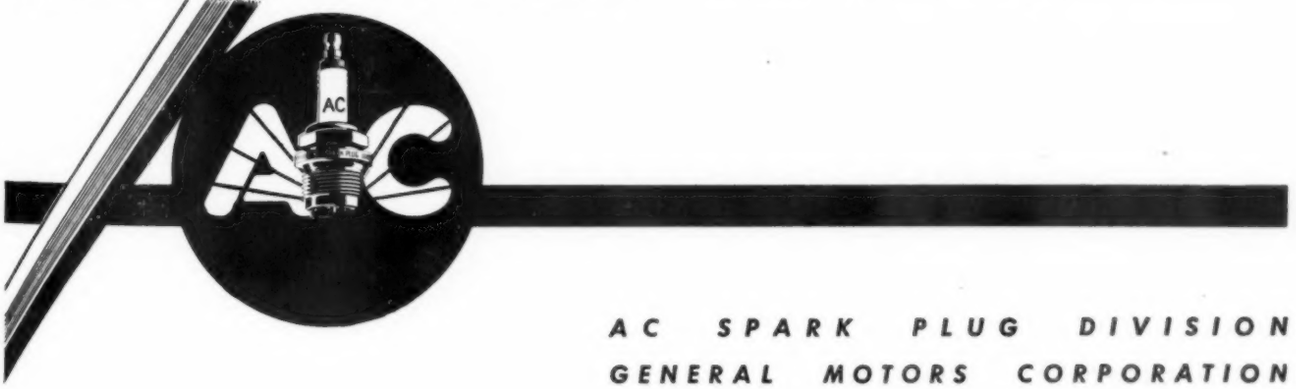
FEW people thought of automotive factory workers as potential gunsmiths, until our country began to arm for defense. Then, because it needed great quantities of war material quickly, the Army asked the industry to build guns—and in a hurry.

AC was asked to produce .50 caliber Browning machine guns. Working closely with army technicians and the small arms industry, AC is now doing that job. And today's machine guns are as much better than the peacetime models as the swords of Toledo were better than the blades of other armorers.

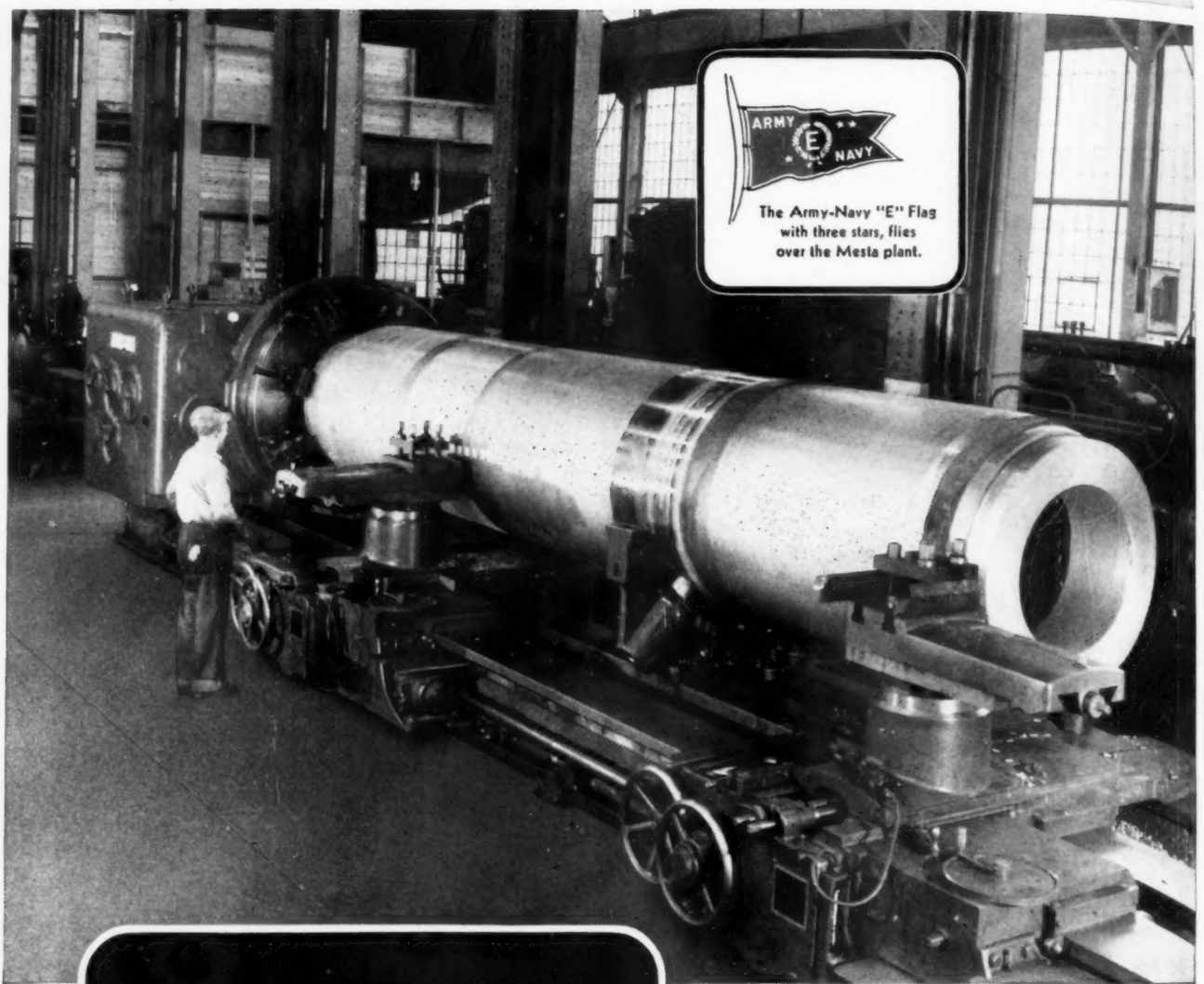
Continuous production methods have improved both the smoothness and the accuracy of the rifling. The element of potential human error has largely been removed from the delicate chambering operation. Substitution of automotive materials, such as Arma-steel, has improved manufacture in other important ways. Electrical resistance riveting assures a snugger rivet fit.

Along with these improvements have gone a huge increase in production per day and a substantial reduction in cost per gun. So, these modern "Toledo blades" are meeting our fighters' needs not only better but faster, and at less cost.

AC plants proudly display the Army-Navy "E" burgee for outstanding production achievements; and also the "Minute Man" flag, which indicates that AC workers are investing 10% of their income in War Bonds and Stamps.



AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION

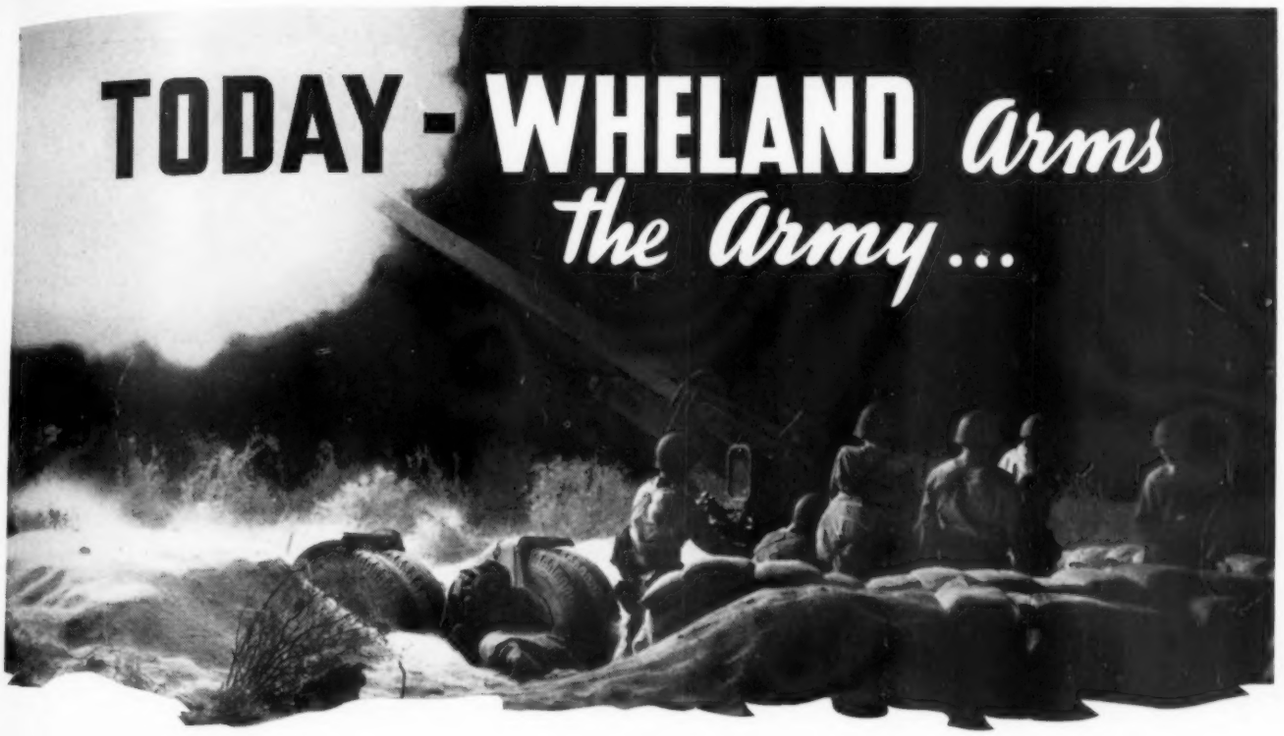


The Army-Navy "E" Flag with three stars, flies over the Mesta plant.

MESTA FORGINGS

One Piece Forged Steel
High Pressure Accumulator Bottle
Produced Complete in the Mesta Plant

MESTA MACHINE COMPANY. PITTSBURGH, PA.



— — With Guns and Windlasses!

TOMORROW - when Victory is Ours

...heroes of the battle fields will join veterans of the oilfields in operating Wheland rotary drilling equipment. Oilfield equipment, like tanks, guns, planes and battleships, must "prove their metal" in action on a thousand fronts. Rotary drilling equipment must be designed and built to send new wells through sand, gravel and solid stone formations — six, eight, ten, twelve thousand feet into the earth — to tap new oil pools.

Wheland equipment has always been manufactured with the same engineering skill and workmanship as the guns, shells and windlasses which Wheland has produced for the U. S. Army. When Victory is Ours, and American manufacturers shift from mechanized war machines to the tools of peacetime industry, Wheland will again devote its facilities and war-trained organization to serving the great petroleum industry so vital to our national welfare in both war and peace.

THE WHELAND COMPANY

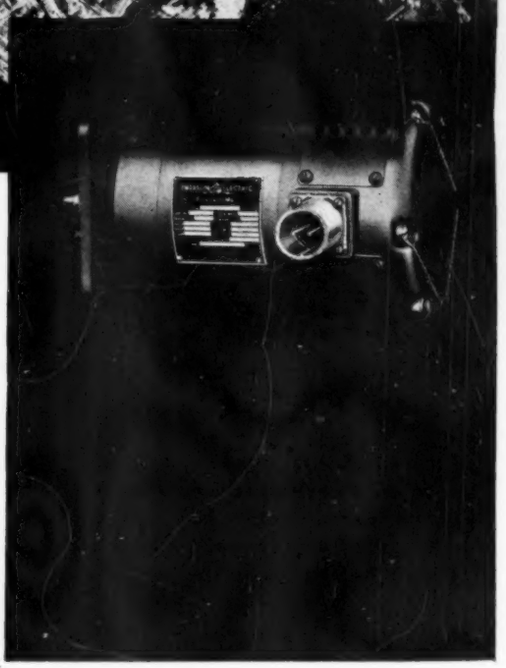
ROTARY DRILLING EQUIPMENT

Chattanooga, Tenn.

Hamburg *Knocked Out!*

PAGES FROM AVIATION'S HISTORY

Fires burning in Hamburg after Allied bombers attacked and smashed the Howaldstwerke Shipyards, important U-Boat builders. (Acme Photo)



All-out aerial warfare has taken on new significance with the virtual obliteration of the arsenal city of Hamburg.

From the design conception of the planes, which took part in this operation, to the actual bombing runs over the target, is presented one of the greatest feats of detail planning and industrial production in all history.

The experience, ingenuity and strength of America's manpower, converted from peaceful pursuits to the job of winning this war is producing results. Hamburg is tangible proof.

Emerson-Electric Aircraft Motors are contributing to ultimate victory—to aviation history.

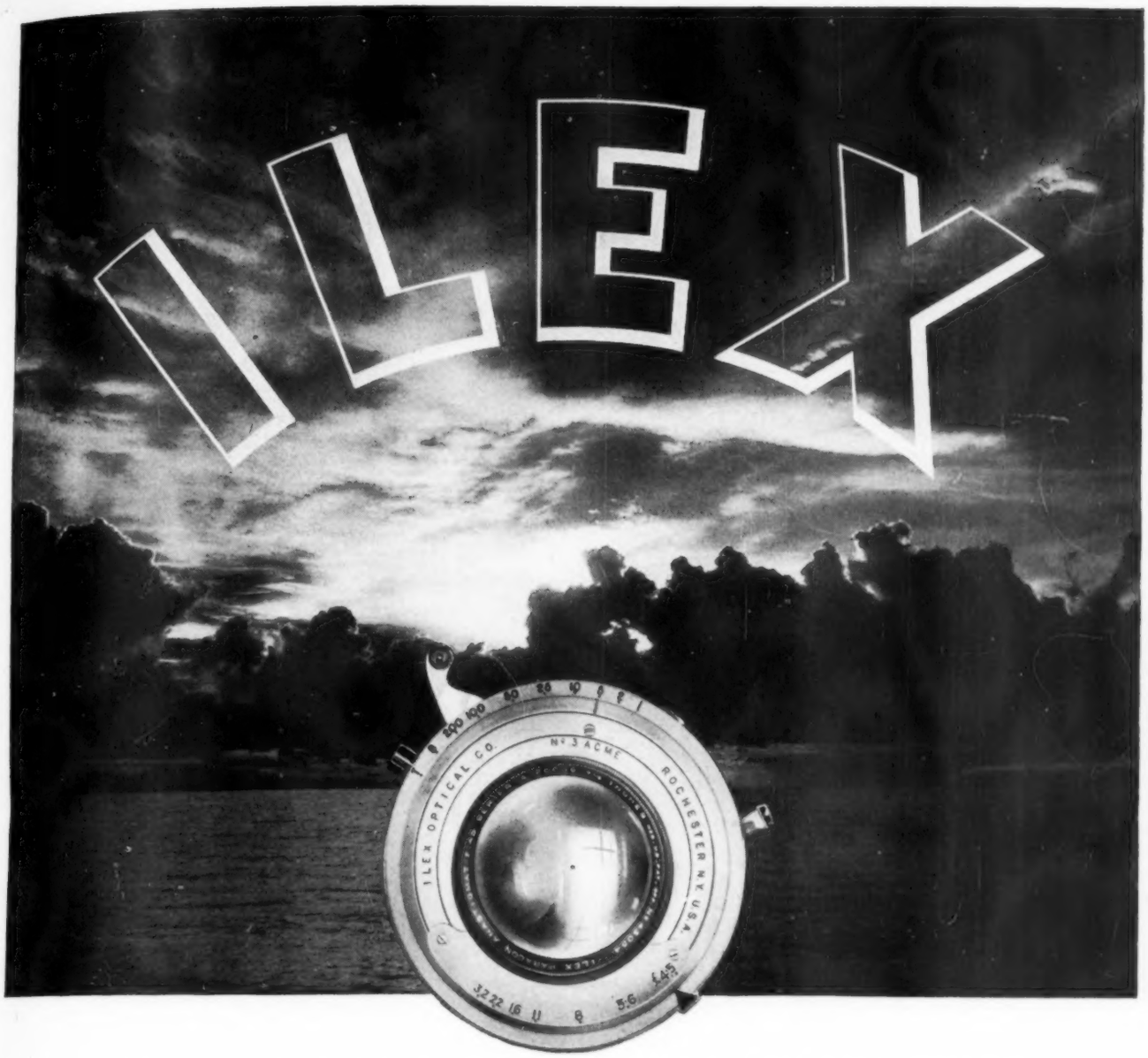
THE EMERSON ELECTRIC MFG. COMPANY
SAINT LOUIS • *Branches:* New York • Chicago • Detroit
Los Angeles • Davenport

Emerson-Electric is now engaged 100% in the production of equipment for the Armed Forces.

338

EMERSON ELECTRIC

MOTORS • FANS • APPLIANCES • A. C. ARC WELDERS



ILEX — A NAME OVER MANY ENEMY SKIES

Newspapers, magazines, and newsreels dramatize the importance of wartime photography. Photographic reconnaissance and interpretation . . . to locate enemy installations, troop movements, ship positions, and to determine bombing results . . . provide a major share of military intelligence today.

In all theaters of war, Ilex shutters, lenses, and precision instruments are in action. For Ilex is concentrating its skill, precision, and facilities in 100% war production.

The priceless knowledge gained from wartime research and production is reflected in Ilex precision optical equipment in service on many battle fronts.

Ilex Optical Co., Rochester 5, N. Y.

ARMY E NAVY

ILEX

SHUTTERS AND LENSES — **OPTICAL INSTRUMENTS**

America's "Thunderbolt," bearing heavy armor, and large and small caliber guns, has proved to be one of the fastest single-engine planes in the world.

Erase another Zero

Yes, you can scratch another Jap from the skies ...if he comes within range of the deadly gunfire of American wings.

And the Axis will see a lot more of these guns. For Electric Power, the mighty force of mass production, is fast at work. Speeding every operation of production—the cutting and shaping, the grinding and drilling, the welding and riveting—Electric Power is helping to turn out thousands and thousands of these powerful, fast-firing guns.

Maintaining the supply of Electric Power to the war production plants of Chicago and Northern Illinois is our chief wartime assignment. And we are giving it our best, for we know its importance in America's war effort.

Electric Power Speeds War Production

By supplying energy for this and scores of other machines, Electric Power aids in the mass production of parts for 20 mm. aircraft cannon.

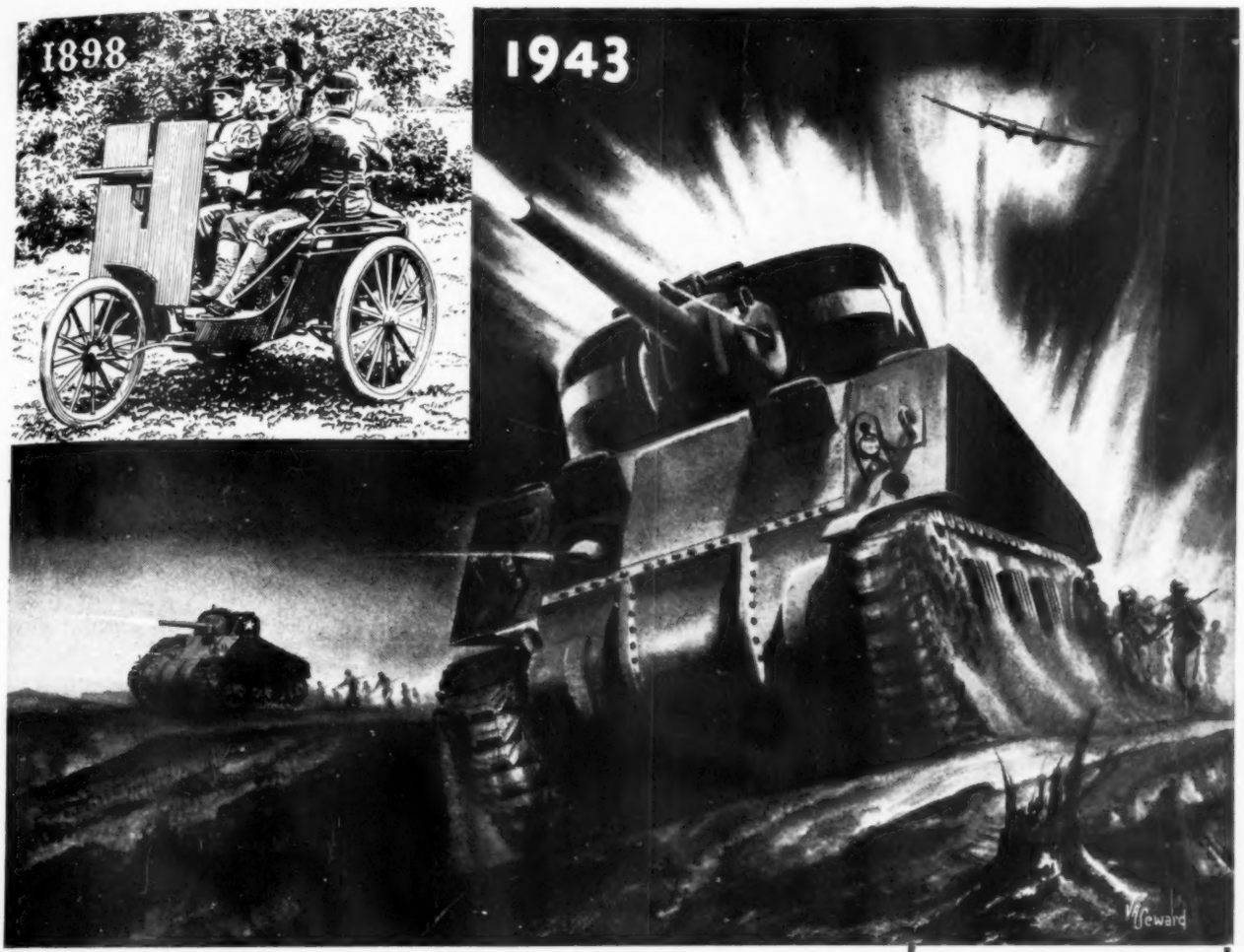
Electric riveting machine in a Chicago area war factory, speeds the assembly of the automatic feeding mechanism used on the cannon for our warplanes.

COMMONWEALTH EDISON COMPANY • PUBLIC SERVICE COMPANY OF NORTHERN ILLINOIS
WESTERN UNITED GAS AND ELECTRIC COMPANY • ILLINOIS NORTHERN UTILITIES COMPANY

Supplying Chicago and Northern Illinois with Vital Electric Power for War Production

TIME AND TIMING MAKE THE DIFFERENCE . . .

World's first armed motor vehicle (left) designed by the American, Davidson, and built at Peoria, Illinois, during the Spanish-American War. It had three wheels . . . one cylinder . . . made a doubtful 8 mph . . . and mounted a single Colt automatic rifle. 40 years later come America's great General Shermans, the mammoth M6's, and the new M10 tank destroyers. Equipped with short-wave radio, special timing devices and cannon up to 105 mm. in size—these heavily armed titans . . . speed at 35 mph . . . strike with deadly precision . . . blast the enemy with fire power timed to the split second!



AS THE TANKS GO CRASHING THROUGH . . .

Americans fight on Elgin Time!

Today, fighting fronts are fluid . . . seldom more than 3000 yards in depth. Armored forces move at high speed and are massed rapidly for assault at given points. Such operations depend on perfect *timing*. Seconds may spell the difference between success and failure.

And to help direct America's armored forces, Elgin has produced thousands of vibration-proof tank clocks. Special Elgin service watches, too, ride on the wrists of the tank crews. In addition, many other types of precision instruments and timing devices are being created by Elgin for America's gallant fighting forces.

For this exacting work, begun even before Pearl Harbor, Elgin was well prepared. Here were craftsmen of rare skills. Here, too, were the finest laboratories and scientific equipment in the watchmaking world.

★ **ELGIN** ★

THE GREATEST NAME IN
AMERICAN FINE WATCHMAKING SINCE 1865

ELGIN SERVICE WATCH—*designed to perform reliably under wartime conditions involving sudden changes in position and wide ranges of temperature. Like all Elgin war equipment, each Elgin service watch is thoroughly American—created of American materials by American craftsmen.*

Elgin manufactures for army, navy and aviation use:

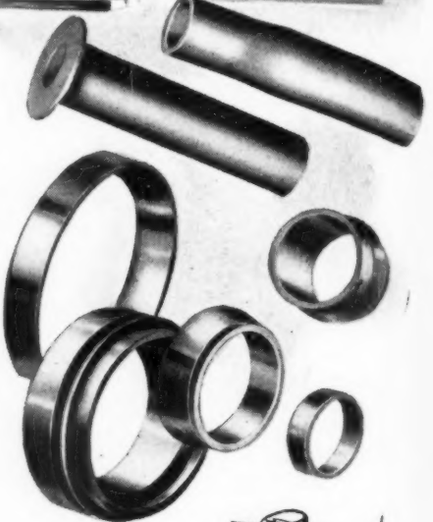
NAVIGATION WATCHES • STOP WATCHES • AVIATION CLOCKS • TANK CLOCKS • SERVICE WATCHES
TIME FUZES FOR SHELLS • JEWEL BEARINGS • SPECIAL TIMING DEVICES FOR NAVAL AND AVIATION USE • RAILROAD AND TRANSPORTATION WATCHES

use TUBING instead

Seamless Steel Tubing Can Take the Place of Solid Stock for Many Mechanical Parts

Babcock & Wilcox Seamless Steel Tubing for many mechanical uses is fast becoming one of the biggest time savers in war-pressed industry. Why waste labor and machine hours cutting hollow parts from solid sections, when with a minimum of re-tooling a better job can be produced by using seamless steel tubing. The wide range of sizes, types of steel, and its adaptability to machining, makes B&W Tubing especially valuable in speeding production. It is also, obviously, more economical. B&W engineers are always available for consultation on any job where you believe steel tubing might be useful.

B&W Seamless Steel Tubing comes in a wide range of sizes and types of steel—Carbon Steels, S.A.E. Alloy Steels, and "N.E." Alloy Steels. It can be furnished cold drawn or hot finished, and can be machined, upset, expanded, swaged and spun. Bulletin T-319 tells the whole story. Copy will be sent on request.



BABCOCK & WILCOX TUBES

HOT FINISHED • COLD DRAWN • CARBON STEELS • ALLOY STEELS

THE BABCOCK & WILCOX TUBE CO., BEAVER FALLS, PA.

TA-1254

A-P PISTOL ROCKET
PARACHUTE SMOKE SIGNAL
PATENTS APPLIED FOR
MARK 3
Minimum Altitude 700 feet
Fired from Standard 1.5
calibre pistol.
Available Only Through
Government Agencies
AERIAL PRODUCTS, Inc.
A-P PISTOL ROCKETS
MERRICK, L. I., NEW YORK

THIS PACKAGE CONTAINS *Time*

IT CONTAINS A VARI-TYPER ENGINEERING MODEL.

Destination -- the drafting room of a war plant. *Duty* — speeding up the lettering of notes, bills of materials and dimensions, on drawings and tracings. It will save hours - days - perhaps weeks - of draftsmen's hand lettering time. As a result, vitally needed equipment will be in production more quickly. And because a typist operates the Vari-Typer three or four draftsmen, relieved of hand lettering, can devote their full time to actual design and engineering.

The *VARI-TYPER* Engineering Model accommodates tracing cloth or paper of any size without folding; produces clean, sharp, legible lettering of various type sizes and styles; eliminates production errors due to poor hand lettering; assures clear blueprints, black and whites, photo-litho and tracing reproductions.

A West Coast shipyard saved 19,500 hours of hand lettering on 6 Liberty ships. A large Philadelphia electrical firm saved the time of 15 draftsmen by using 3 Vari-Typers. General Electric, Worthington Pump, Boeing Aircraft, Electric Boat — these are only a few of the scores of companies which report similar savings.

Write for complete information, or let us make a free demonstration in your own plant on your own work!

Other models of Vari-Typer are also available for use in composing for instruction books, bulletins, parts lists, house organs, etc., for reproduction by photo-offset, multilith, mimeograph, gelatine or any other reproduction processes, saving 50% or more in time, materials and cost as compared to ordinary methods.

RALPH C. COXHEAD CORPORATION
333 SIXTH AVENUE • NEW YORK 14, N. Y.

☐ Please send information on Engineering Model Other Models ☐ Please arrange appointment for demonstration.

Name ..... *Title* .....
Company .....
Address .....
City ..... *State* .....

TEXT COPY SET ON VARI-TYPER

I know what Freedom means

I'm lonesome, and sort of scared.

This morning the Boss put me in this crate, and right away I knew something was wrong. Then he scratched my ears longer than usual, all the time with a strange, extra-serious look in his eyes.

He said he was going gunning for varmints, and I started to get excited. But he said no, these were a different breed. Two-legged ones. "And, Jeb," he said, "you're going to live with strangers till I get back. Be a good dog about it." He talked a lot about *freedom* . . . and how, if he didn't win out over those varmints, he'd probably be in a crate, too, and strangers would be shouting orders at him.

Well, I know what freedom means, and I want it . . . for me and for the Boss. I want to be free to run through my favorite fields and woods again. Free to nose after quail. Free to see the Boss, with a smile on his face, try to pretend he isn't as excited as I am.

He said he'd come back to me . . . that life would be the same again, or better. So I'll be waiting . . . no matter how long it takes!

* * *

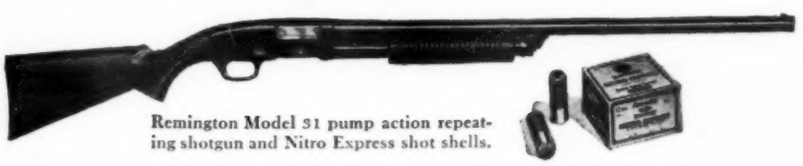
Here at Remington we are thankful that we are able to help Uncle Sam go gunning after those "varmints" . . .

1. *Since Pearl Harbor, Remington has produced more than* ***ten billion*** *rounds of military small arms ammunition . . . three times as much as was produced by the entire country in all four years of World War I.*

2. *Every working day, Remington produces* ***more*** *than enough military rifles to equip an entire infantry regiment at full fighting strength.*

But, after the war is won, we will welcome the return to our peacetime business . . . when once again we can serve our sportsmen friends with Remington shotguns and rifles, Nitro Express shells, Kleanbore Hi-Speed .22's, and Core-Lokt big game bullets. *Remington Arms Company, Inc., Bridgeport, Conn.*

"Nitro Express," "Kleanbore," and "Hi-Speed" are Reg. U. S. Pat. Off.; "Core-Lokt" is a trade mark of Remington Arms Co., Inc.



Remington Model 31 pump action repeating shotgun and Nitro Express shot shells.

Remington

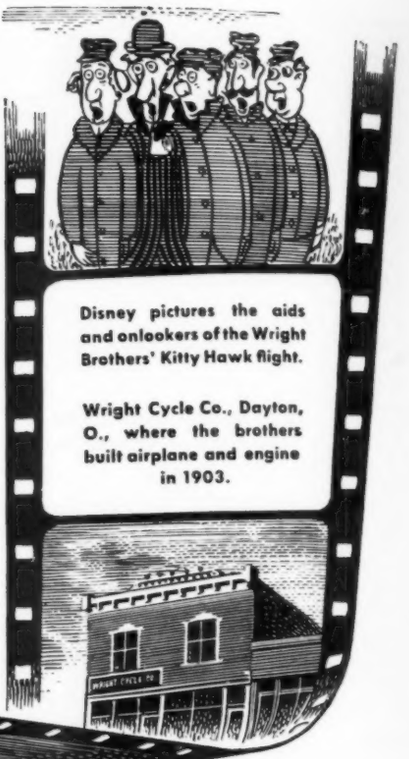
DU PONT

The Five Witnesses Were Too Amazed to Cheer

THE WRIGHT BROTHERS knew their machine would fly. But the five witnesses, unaware of the painstaking study and experiment which had gone into the plane, were too amazed to cheer.

The comprehensive research program which brought initial success has characterized all subsequent Wright development. In the modern Cyclone engine it has made possible greater power for less weight, space, and fuel than is produced by any other type of powerplant.

The story of Wright is the story of flight as shown in Walt Disney's "Victory Through Air Power". Now, as in the past, Wright supplies the engines for the fastest and most powerful military and transport aircraft. For the even larger and more efficient planes now under construction, Wright is again providing the power.



Disney pictures the aids and onlookers of the Wright Brothers' Kitty Hawk flight.

Wright Cycle Co., Dayton, O., where the brothers built airplane and engine in 1903.

The first flight could have been made within the wing-span of a modern bomber.

LIGHT · COMPACT · POWERFUL

Wright

ENGINES

WRIGHT POWERS THE TONNAGE OF THE AIR

Air lightning strikes *FROM THE GROUND!*

The threat of invasion hung like a black cloud over Australia — the Japanese had crossed the Owen Stanley Range and were pushing down against Port Moresby, one of the last Allied footholds on New Guinea.

Bombing attacks and rugged infantry action slowly rolled them back, and before they could reorganize to strike again a chain of American airfields — scores in number — suddenly appeared on the northern coast of the peninsula, flanking the enemy's bases.

Those fields were slashed out of the jungle by "Caterpillar" Diesel Tractors at a speed never before imagined. Acres of palm trees were toppled and shoved aside by the hard-hitting bulldozers; hollows were quickly filled; steel landing mats were slapped into place on the long runways. And while Tojo's scouts were still guessing, swift Yankee fighter planes and grim bombers had control of the air.

The Axis has nothing to match the toughness and versatility of "Caterpillar" Diesel Tractors, Graders, Engines and Electric Sets. These machines are not only building air bases and roads but hauling guns, towing disabled tanks, clearing beachheads, powering pumps and air compressors, and generating current for lights and communication on land and sea.

The armed forces have first call on all new "Caterpillar" production. But thousands of older machines are faithfully performing wartime tasks at home. The skill and specialized equipment of "Caterpillar" dealers are keeping "Caterpillar" Diesels at work with the least possible expenditure of money and critical materials.

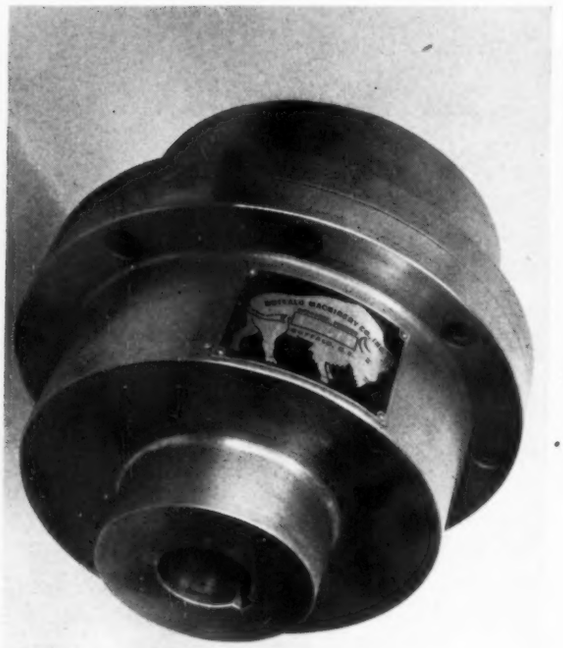
CATERPILLAR *DIESEL*

REG. U.S. PAT. OFF.

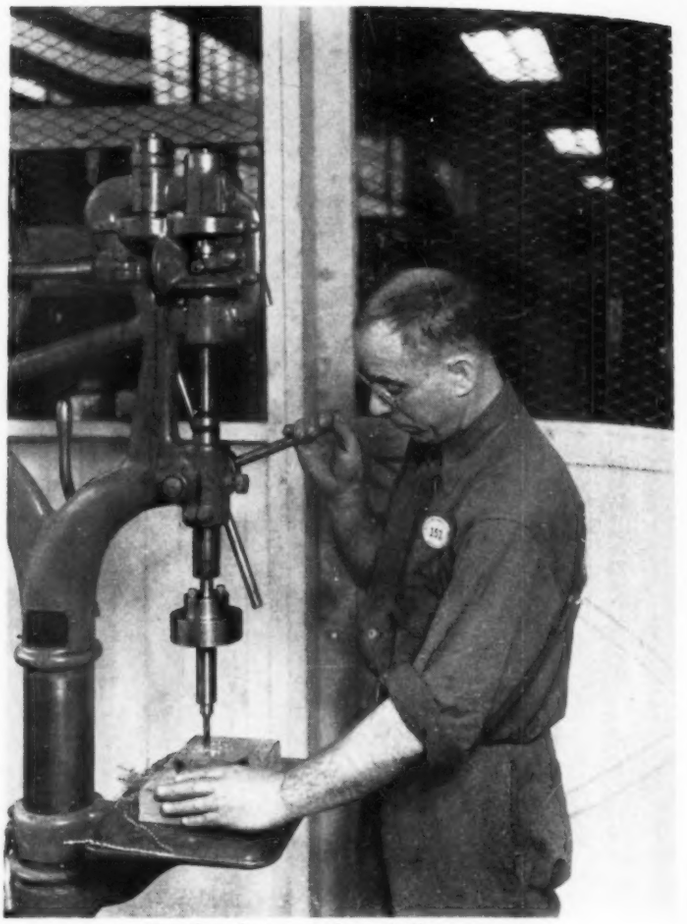
CATERPILLAR TRACTOR CO., PEORIA, ILLINOIS

TO WIN THE WAR: WORK—FIGHT—BUY U. S. WAR BONDS!

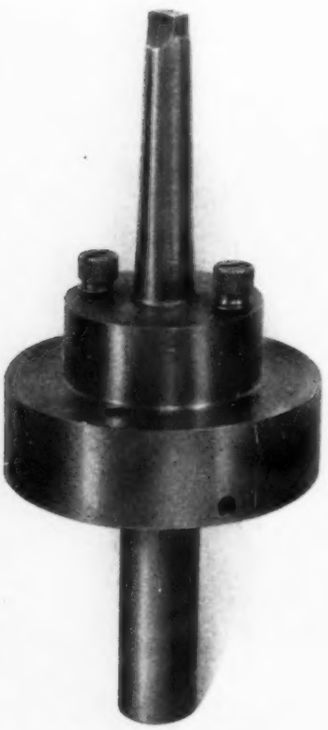
BUFFALO CONTROL COUPLINGS



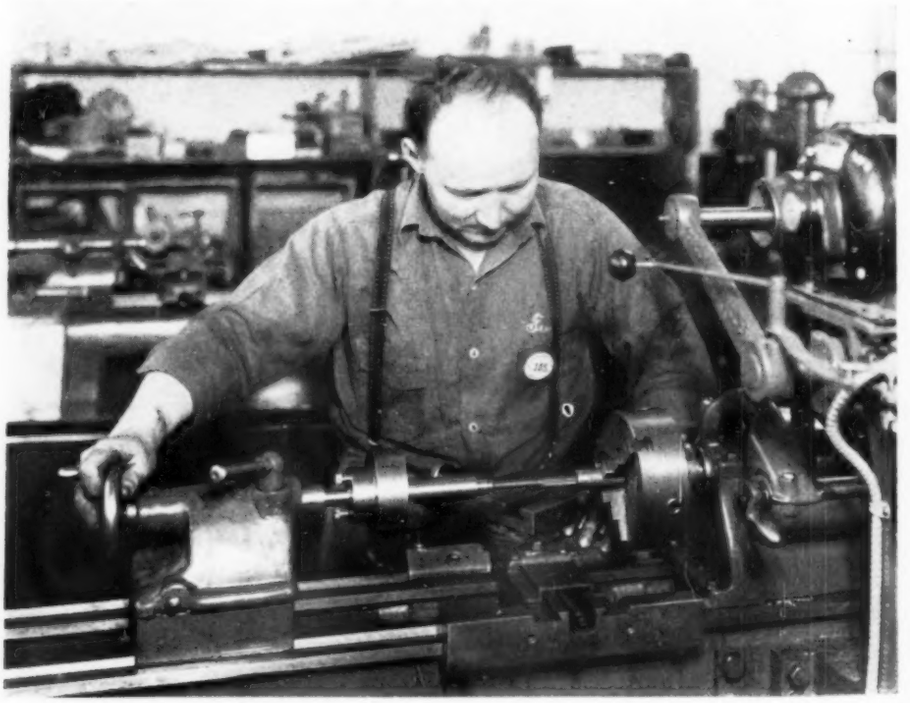
BUFFALO CONTROL COUPLINGS are available in both Torque and Shaft types. The Torque Control Coupling eliminates drill and reamer breakage and is manufactured in single- and multiple-disc types. The Non-Spark Shaft Coupling is designed as an automatic safeguard between driving motor and driven unit.



Coupling being used on drilling operation.



Single Disc Type.



Coupling being used on Reaming operation in lathe.

BUFFALO MACHINERY CO., INC.

833-841 GRANT ST. Ordnance Division BUFFALO, N. Y.

Easy to Claim ...hard to prove

New materials and new methods of manufacturing are created through vision. Frequently that vision leads originators of new materials and methods to look beyond the known horizon, for new applications of their ideas.

True, you can replace certain steel parts with plastics, but the plastic substitutes seldom provide *all* of the advantages of steel.

True, you can join pieces of steel together, to produce a more complex assembly, but the economy of such a method may be doubtful, compared with casting that assembly as a unit.

True, you can replace a steel casting with a cheaper metal part, but it is shortsighted to think that such a substitution can be made without losing something of value.

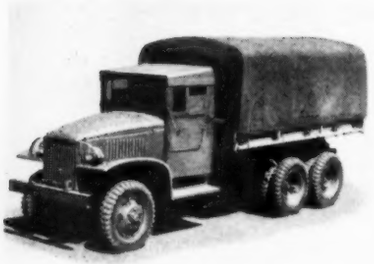
Steel in cast form does not pretend to be the final answer always, but it does afford strength and toughness and rigidity and economy in production that no substitute material can give you.

And such advantages have been *proved* in actual practice—not merely conjectured as interesting possibilities.

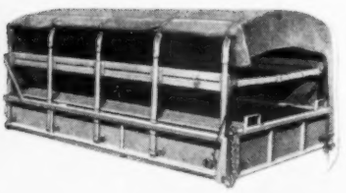
The Steel Founders' Society of America, Cleveland, Ohio

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

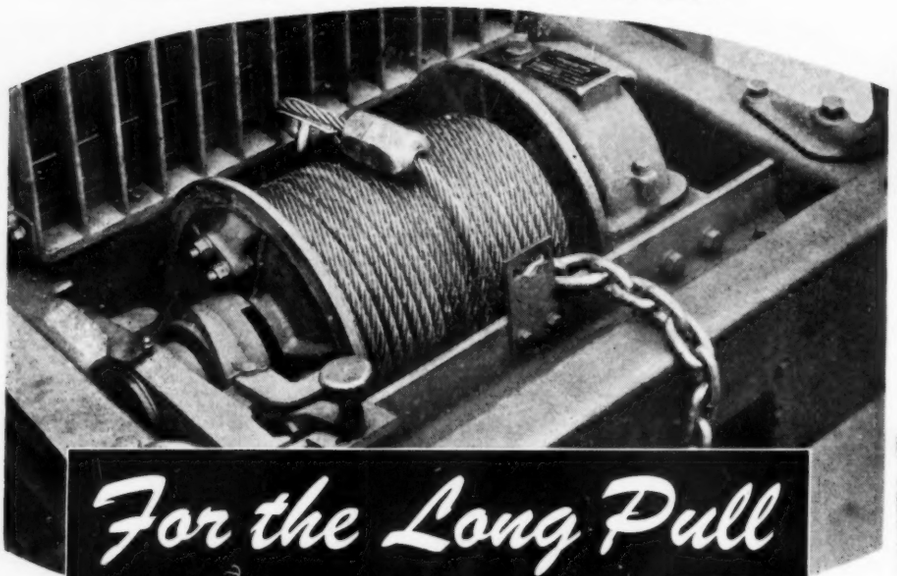


Cargo dump unit for transporting material or troops



Cargo body equipped for troop transport

Heil Hydraulic Bulldozer



For the Long Pull

. . . dependable, durable HEIL equipment serves our armed forces

Heil Cable Scrapers

Heil Aircraft Refueler

Heil Cargo Dump Unit

One reason for the immediate usefulness of the Heil organization, starting in the very early stages of our defense program, has been the fact that Heil's broad range of peace-time products is so closely related to basic war needs.

The Heil Company therefore has been able to utilize its engineering talent and manufacturing experience to the greatest possible advantage in war production. Illustrated are just a few of the many Heil units (see list below) which are playing an active part on every fighting front.

This talent and experience are available to you — with facilities for handling major undertakings with results that are creditable to all concerned. Consult Heil. Let our engineering staff co-operate with yours in solving any problem on which our specialized background may be of assistance to you. AO-3

HEIL
War-time Products

- Torpedo Tubes (PT Boats)
- Bogie Axles
- Tank Hulls
- Smoke Generators
- Fire Fighter Trucks
- Aircraft Gas Refuelers
- Aircraft Oil Refuelers
- Transportation Tanks
- Cargo Bodies
- Air Cargo Hi Lift Trucks
- Winches
- Shell Washers
- Hydraulic Trail-builders
- Hydraulic Bulldozers
- Hi-Speed Scoops
- Cable Scrapers
- Tamping Rollers
- Cabledozers
- Bottom Dump Wagons
- Cargo Dump Bodies
- Oxygen Generator Trailers
- Portable Shop Trailers
- Water Tanks
- Portable Pipe Line Equipment
- Portable Fuel Pumping Units
- Tank Idler Wheels
- Bridge Bodies and Cranes
- Pressure Tanks
- Swing Cranes — Tractor Mounted
- Mobile Cranes — Rubber Tire Mounted
- Power Control Units
- Wrecker Units

THE HEIL CO.

GENERAL OFFICES • MILWAUKEE 1, WISCONSIN

PRESSES ★ ★ ★ FOR PLANES

America's call for aircraft . . . by the tens of thousands . . . must first be answered with machines for production. Ingots of lightweight alloys must be forged, a myriad of parts must be drawn, shaped or stamped —and hydraulic presses are the tools used for performing these vital operations.

Although we are contributing our utmost to the nation's need for hydraulic presses, our engineering department stands ready at all times for consultation on your hydraulic press problems.

ESTABLISHED 1803

R.D. Wood Co.

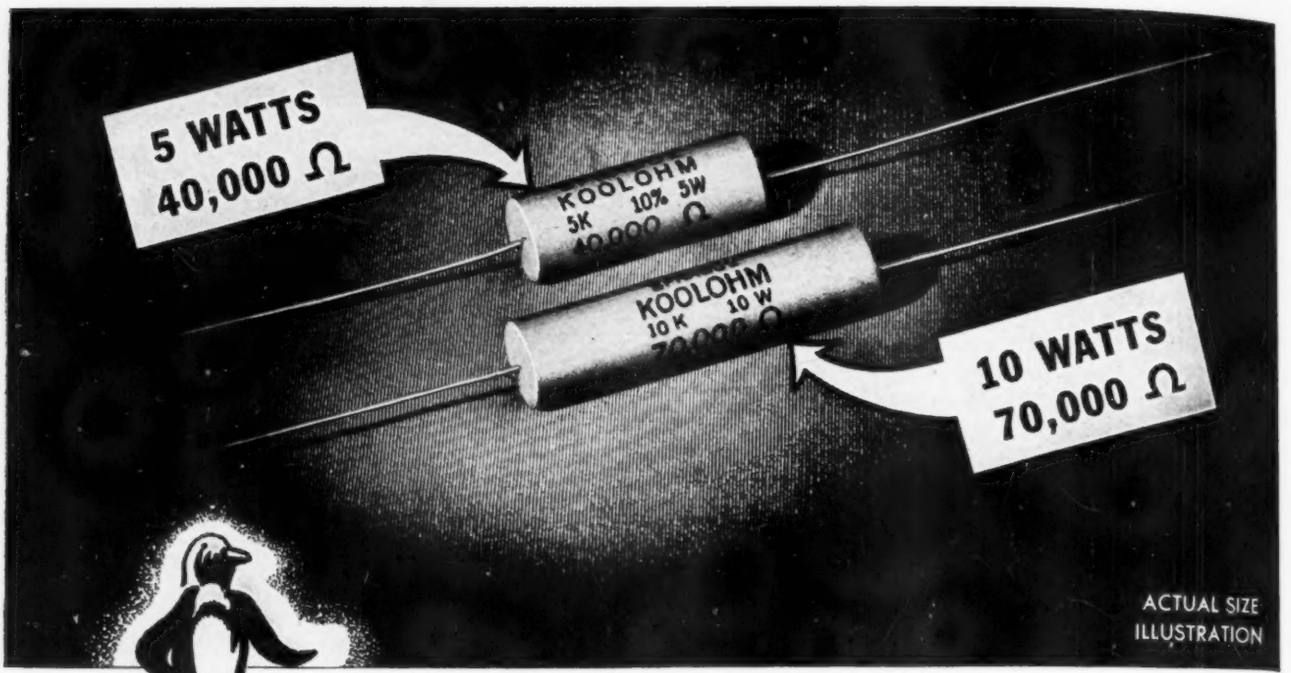
PHILADELPHIA, PA.

This 3000-ton high speed forging press was specially designed for forging aluminum and magnesium alloy ingots. It is but one of the many types of R. D. Wood presses in use throughout industry.

★ ★ ★

HYDRAULIC PRESSES AND VALVES FOR EVERY PURPOSE

THESE·RESISTOR WATTAGE RATINGS MEAN WHAT THEY SAY



...Regardless of the ohmic values

If it's a 5-watt Koolohm, use it at its full 5-watt rating—regardless of whether it has a 1 ohm or a 40,000 ohm value! If it's a 10-watt Koolohm you can count on it dissipating a full 10 watts whether the resistance value is 1 ohm or 70,000 ohms!

In brief, there's no need to "play safe" with Koolohms. You don't have to use a larger resistor than you actually require. You can forget your worries as to whether the wire size is big enough to carry the current and the resistor body large enough to withstand the temperature rise involved. *You can use any Koolohm at its full wattage rating—any time, anywhere!*

This freedom of use is made possible because Koolohm design is based upon a time-tested, inorganic insulating material. This is sintered on the wire *before it is wound*—at 1000° C.! The insulation is flexible, and has a dielectric strength of 350 volts per mil at 400° C.!

Samples free to industrial users. Catalog on request to all who are interested in better, more dependable resistors.

SPRAGUE SPECIALTIES CO., Resistor Division, North Adams, Mass.

KOOLOHM WIRE IS 2¼ TIMES LARGER

Although Koolohm Resistors themselves are no larger—often smaller—than ordinary resistors, their wire is 2¼ times larger in actual cross-sectional area! This is especially important in the high resistance values where very fine wires so often fail to carry the currents involved in power resistor operation, or to withstand the corrosive effects of operation in high humidities *Play safe* with Koolohms!

KOOLOHM

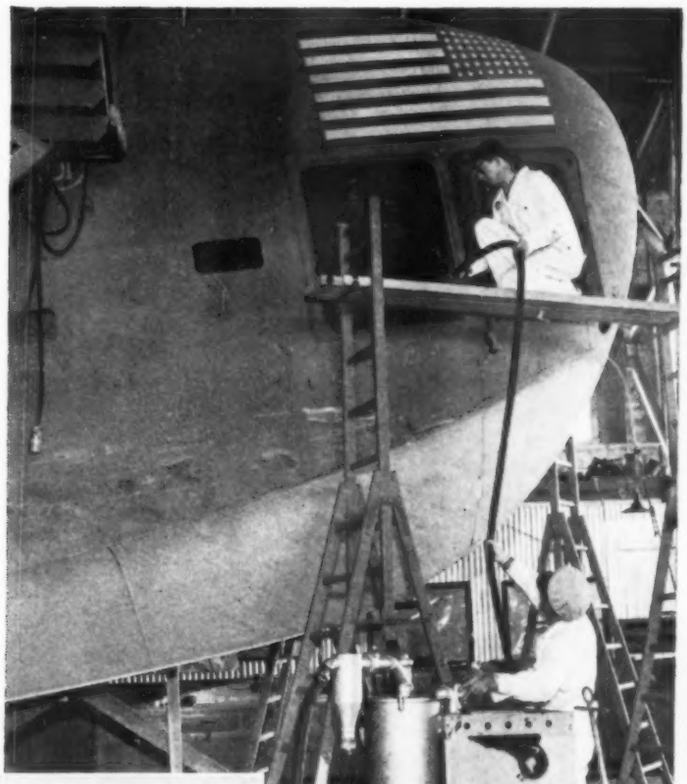
REGISTERED TRADEMARK

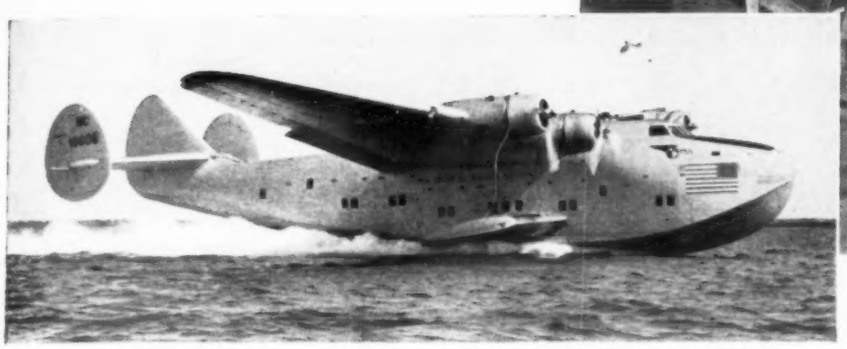
TURCO MULSINE

MAKES 'EM

Ready For Long Hops

To the four corners of the earth!





Cleaning With Turco Mulsine Is Standard Pan American Airways System Maintenance Procedure.

Pan American Clippers, and other planes it flies for the U. S. Army and Navy, return from vital missions carrying the grime of weather and wear, demand the best cleaning care. With Turco Mulsine—clean-up jobs are performed at low cost and in minimum time, thus saving man-hours. Turco Mulsine mixed with kerosene and sprayed cold, quickly removes grease and grime and leaves no residue. It is a potent but harmless emulsifier that makes oils and petroleum solvents mix readily with water.

Consult the Turco Field Service Specialist about any of your industrial maintenance problems. This Turco service is at your command free of charge.

3rd WAR LOAN BACK THE ATTACK

TURCO PRODUCTS, INC.
6135 So. Central Ave., Los Angeles 54

Send information on Cleaning the Mulsine Production Line Procedure way.

NAME..... TITLE.....

FIRM .....

ADDRESS..... STATE.....

On Your Letterhead, Please 48-113

TURCO PRODUCTS, INC.

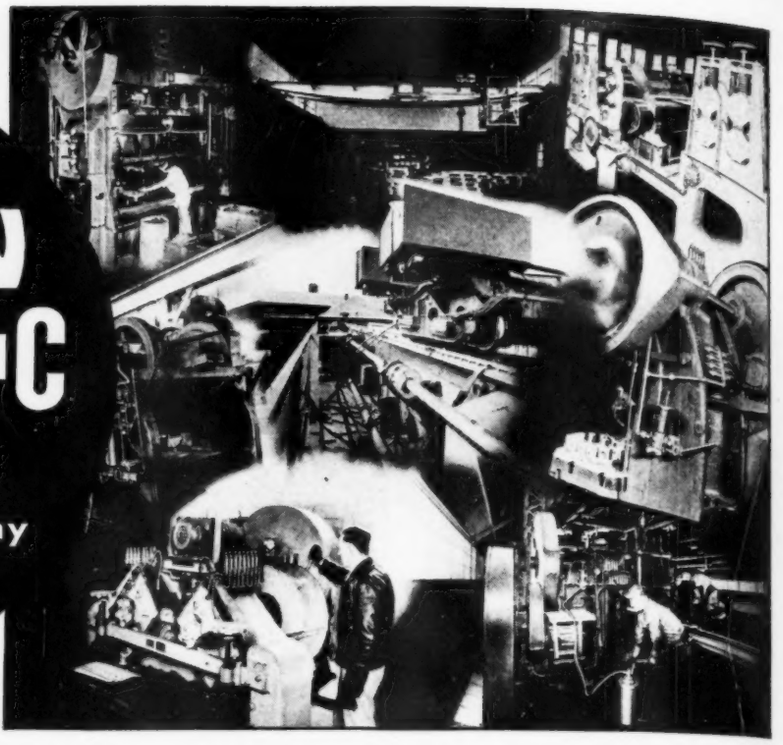
SPECIALIZED INDUSTRIAL CHEMICAL COMPOUNDS

MAIN OFFICE & FACTORY: 6135 SO. CENTRAL AVE., LOS ANGELES 54
CHICAGO OFFICE & FACTORY: 4856 SO. HALSTED ST., CHICAGO 9
SERVICE MEN AND WAREHOUSE STOCKS IN ALL PRINCIPAL CITIES

★

LINCOLN CENTRO-MATIC SYSTEMS

are being used in many war-production plants



LET THE LINCOLN MODERN METHOD of CENTRALIZED LUBRICATION help your factory avoid bearing failures

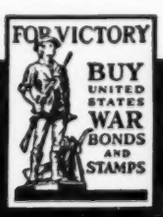
Lick the man-power shortage problem... Get away from the danger—and loss of time—of having a maintenance man climb all over big machines in order to lubricate bearings.

You can cut war-production delays—and you can lower your lubrication and maintenance costs by equipping machines with Lincoln Centro-Matic Lubricating Systems.

A Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a power operated or a hand operated Centro-Matic Lubricant Pump. A power operated system can be either time clock control or push button control . . . The injectors can be grouped in manifold or located separately at each bearing. In either arrangement only a single lubricant supply line is required . . . Easily installed on new or old machines . . . Please write for Bulletin 671, and send us blueprints of the machines you plan to lubricate. Our engineers will gladly make recommendations.

The ARMY-NAVY PRODUCTION AWARD for high achievement in the production of war equipment, conferred upon the Lincoln Engineering Company has had a star added. This star symbolizes 6 more months of exacting service to our Armed Forces, delivering vital materials so necessary for ultimate Victory.

Write us today for complete information



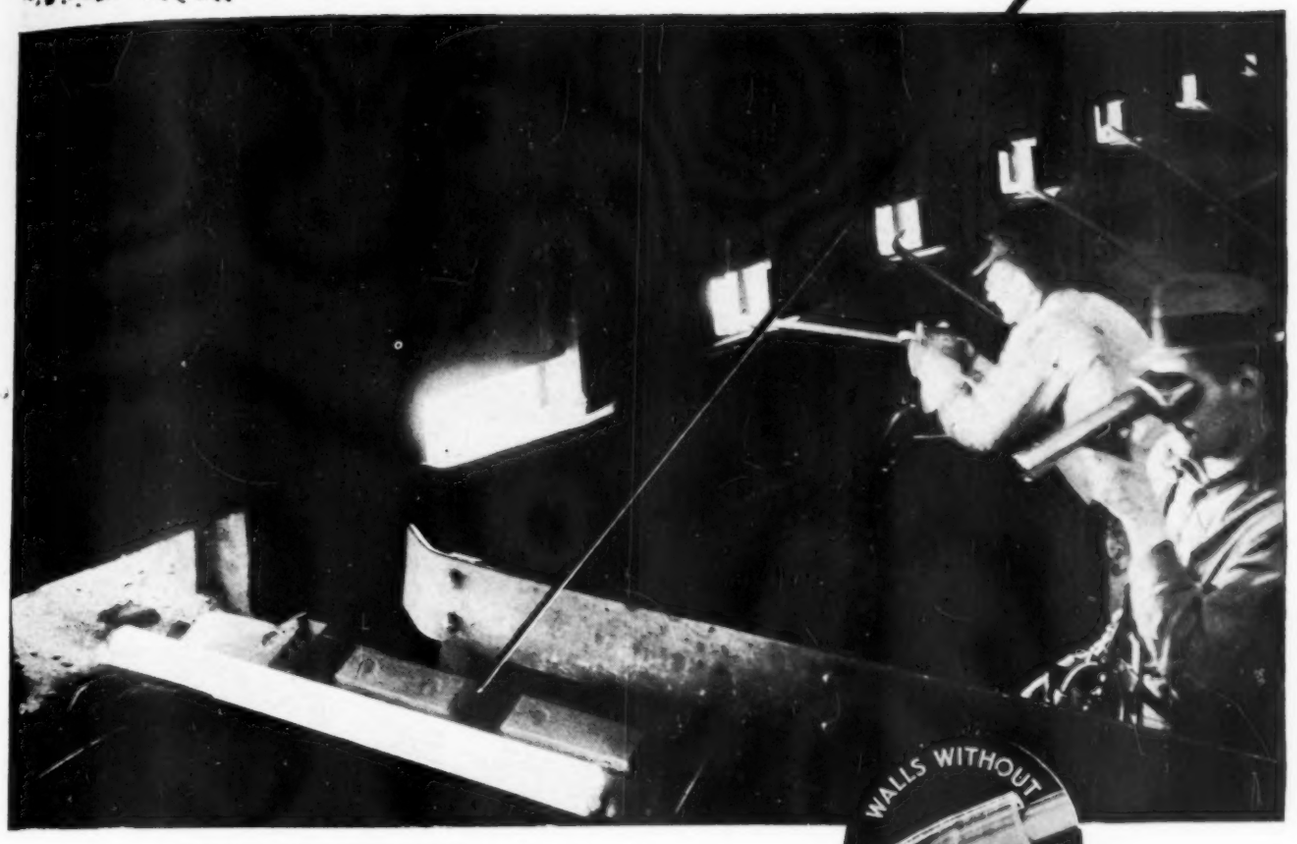
143-25

LINCOLN ENGINEERING COMPANY

Pioneer Builders of Engineered Lubricating Equipment

ST. LOUIS, MO., U. S. A.

RESISTANCE TO BATTLE SHOCK *starts here*



HEATING BILLETS OF SOLID STEEL in preparation for piercing—the first step in making seamless tubing.

THIS is where *tough* seamless steel tubing is born—the kind that makes tanks, trucks, jeeps and other mobile equipment stand up under terrific pounding—the kind that brings battered airplanes back home, and the kind that helps absorb the shock of firing apparatus on land, on sea, and in the air.

Correct heating of the solid billet of steel is a step in tube making that receives special attention in NATIONAL Tube Company mills. Here, only highly skilled workmen are permitted to handle this important operation to make sure it is exactly right for the piercing process that follows.

Because the wall strength of a tube pierced from a solid billet of steel is absolutely uniform and therefore dependable, NATIONAL Seamless Tubing is being increasingly used in all types of military equipment. It offers the strongest construction for the least poundage, and saves time and labor in finishing operations. By substituting tubing for solid forgings parts often weigh 25% to 50% less, and every pound of steel saved is important to war production.

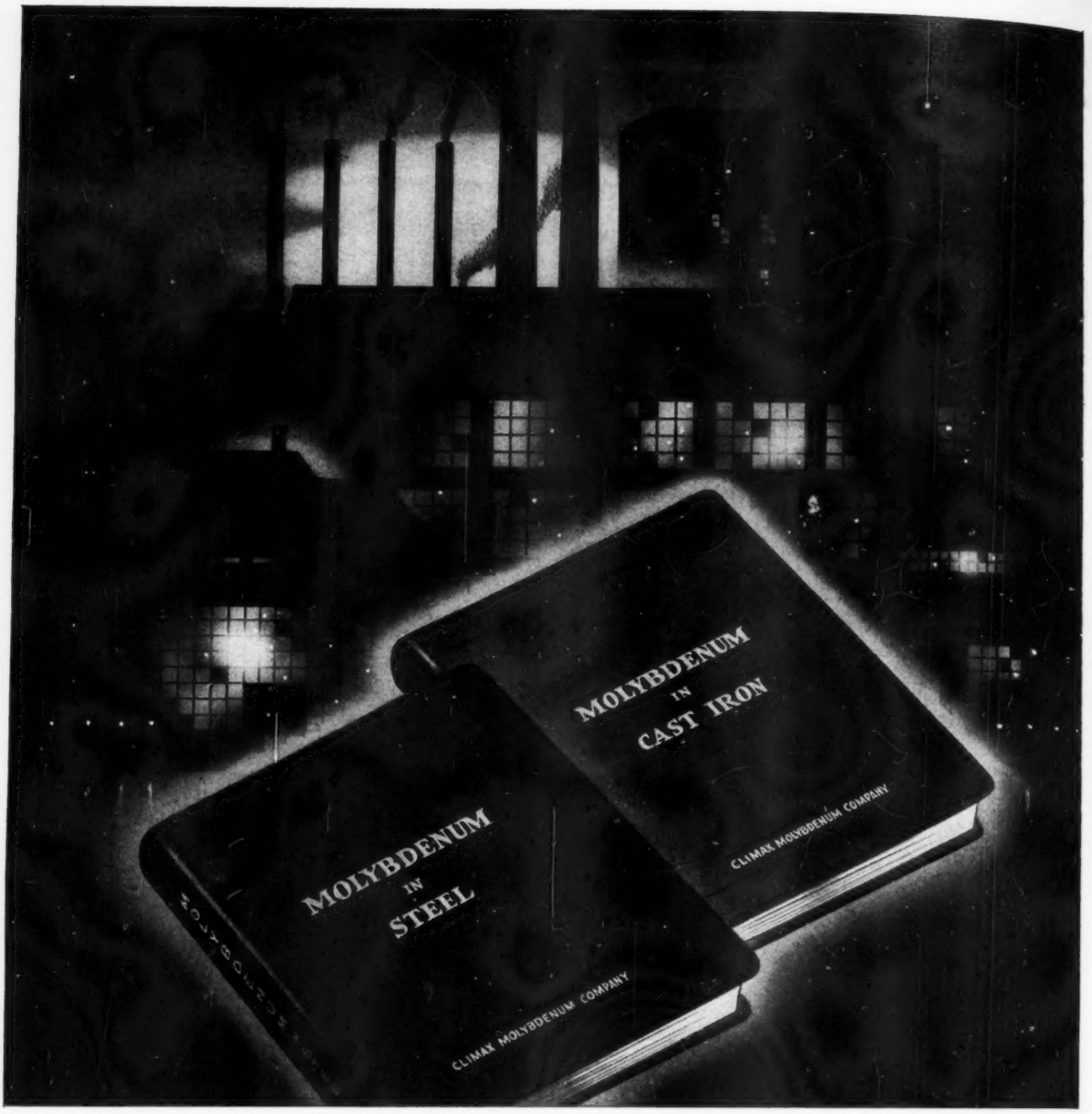
NATIONAL Tube Company engineers will be glad to assist in selecting the proper type of seamless tubing for ordnance work, from the smallest to the largest size in various wall thicknesses.

NATIONAL TUBE COMPANY

PITTSBURGH, PA.

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Export Company, New York

UNITED STATES STEEL



PRACTICAL DATA FOR PRESENT PROBLEMS

Here are two books designed to help users of Molybdenum steels and irons to conserve all alloying elements, and possibly steel and iron, by getting the most in the way of strength, toughness and wear resistance with the lowest alloy content.

"MOLYBDENUM IN STEEL" covers the fundamental metallurgy of Molybdenum steels. Heat treatment – physical properties – applications – of a number of these steels are treated at length.

"MOLYBDENUM IN CAST IRON" covers the effect of Molybdenum in gray iron, giving suggested analyses for practical applications and detailed discussion of high strength (60,000 p.s.i. and up) irons.

Both books will gladly be sent free on request.

Climax Molybdenum Company
500 Fifth Avenue · New York City

MOLY

GUTS alone won't fly 'em

. . . it takes Oil

Here is the *boy* who went to war . . . the *man* who will come back. What it takes, he's got! Deadly skill . . . cold-as-ice nerve. He flys like a falcon, fights like a demon, gives quarter while asking none.

But his wings will be pinioned and his fighting spirit earthbound . . . without *gasoline* and *oil* to take his plane aloft.

For *mobility* . . . the capacity to move about freely and rapidly in the sky, on the earth, and on and under the water . . . depends today on the *motivating* and *lubricating* powers of oil and gasoline which comes from oil. *All* of the modern vehicles of war and peace are useless as clods without *these* to keep 'em going!

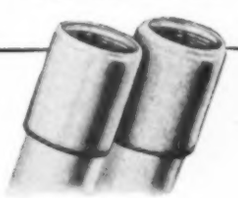
The point should be obvious:

The most basic need of America, next to food, is *oil* and the *mobility* it *transmits* to *all other resources.*

The oil producing industry should be given unqualified first consideration! It must not be limited by shortages of manpower and materials, nor lack of incentives. The vital job of maintaining full production from existing oil fields, and exploring to replenish fast dwindling reserves, dare not be restricted. Unless America keeps its *mobility* . . . it may lose everything else!

***MOBILITY* is the Force of America**

***...and Mobility depends on* OIL**



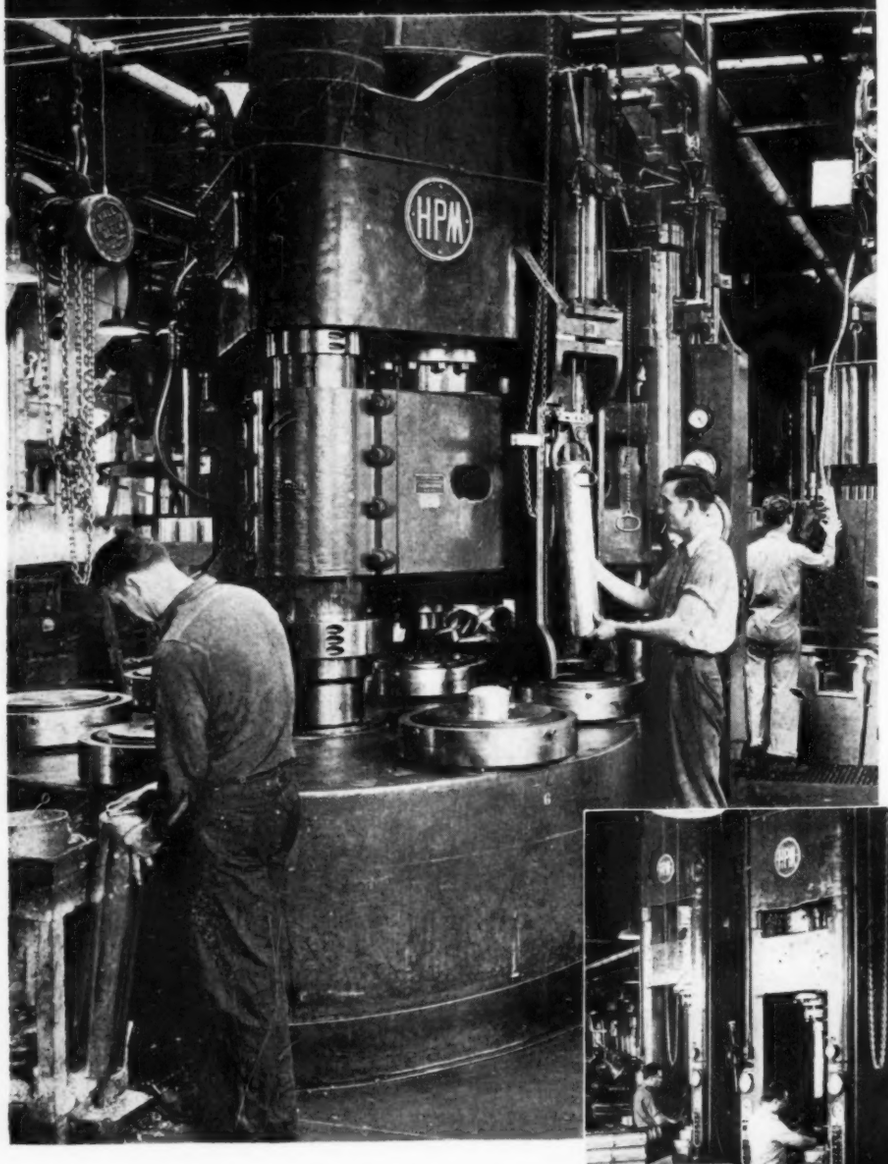
PITTSBURGH STEEL COMPANY

Grant Building (P) Pittsburgh, Pa.

SERVING THE PRODUCING AND REFINING INDUSTRIES WITH DRILL PIPE, CASING, OIL WELL TUBING, REFINERY PIPING

Final Victory assured by

HPM "All-Hydraulic" FASTRAVERSE CARTRIDGE CASE PRESSES!



H-P-M FASTRAVERSE presses are establishing new records in the production of artillery shell cases. There are H-P-M presses for cupping, drawing, redrawing, heading and tapering operations, regardless of the size of the shell case. Each press is designed for high speed operation, and employs the H-P-M closed circuit operating system, permitting valveless and shockless reversal. H-P-M presses are completely self-contained, each being equipped with an H-P-M HYDRO-POWER radial hydraulic pump.

If your production includes pressure applications—*write for details*. An H-P-M FASTRAVERSE press will do the job faster and cheaper.

THE HYDRAULIC PRESS MFG. CO.

Mount Gilead, Ohio, U. S. A.

District Sales Offices: New York, Syracuse, Detroit and Chicago — Representatives in Principal Cities

Above—A 2000-ton H-P-M cartridge case heading press equipped with a six station turret, permitting continuous production. Press will accommodate two heading tools which can be automatically operated in sequence.

Right—H-P-M FASTRAVERSE cartridge case presses drawing large artillery shell cases.

All presses illustrated are installed in the plant of one of America's largest producers of artillery shell cases

CLE-AIR

CLECO-GRUSS

BOTH HYDRAULIC AND PNEUMATIC TYPES—Our Cle-Air shock absorbers are both hydraulic and pneumatic—the resiliency of air absorbs the shock while the hydraulic resistance of oil prevents recoil. Our Cleco-Gruss shock absorbers are pneumatic (inflated like a tire).

SUITABLE FOR ALL TYPES OF VEHICLES—Cle-Air units are so sensitive that they are equally efficient on heavy trucks or comparatively light-weight ambulances. Cleco-Gruss units are of the extra-heavy-duty type, being widely used on 6 x 6 trucks.

PROTECT TRUCKS IN MANY WAYS—Cleveland shock absorbers reduce wear and breakdowns by "short-circuiting" shocks before they reach the body, chassis and springs. Tire wear is decreased because "sidesway scuff" and "buffing," due to rolling and bumping, are eliminated. Steering is easier; driver fatigue and load damage are also lessened.

Complete information and engineering specifications supplied promptly upon request.

BOMBER NURSE

A typical example of B. F. Goodrich leadership in rubber

WHEN bullet-ridden, flak-torn Flying Fortresses come limping home after a foray over Europe or Jap-held territory, alert, skilled repair crews quickly make them as good as new.

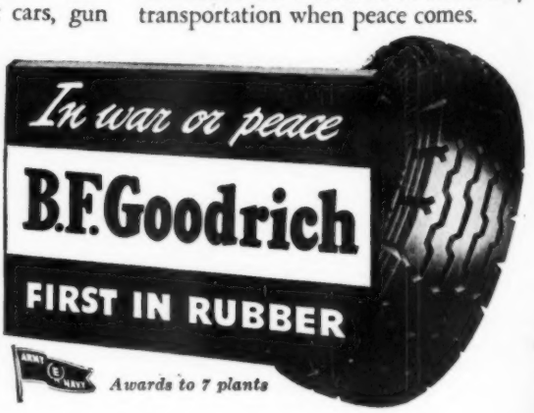
One secret of success in handling such tough jobs as on-the-spot replacement of a motor or a wing section is the go-anywhere tractors which serve as nursemaids to these big bombers.

Equipped with band block rubber tracks and rubber-covered track wheels to give them peak traction and maneuverability, these tractors can operate in jungle slime, snow, or sand as well as over a paved highway—haul ammunition, replacement parts, fuel, or the planes themselves to points where they can't be taxied.

The special rubber track is an outgrowth of the endless band rubber track invented years ago by B. F. Goodrich for use on the farm. Later the Army adopted the endless band idea for its half-track scout cars, gun carriers, and general utility units. But between the original track and those in use today was one of the most intensive research programs ever undertaken by The B. F. Goodrich Company, working in close cooperation with the U. S. Army Ordnance Department.

Now rubber track is being made with substantial amounts of synthetic rubber in a compound that has proved equal in wear resistance to natural rubber.

Endless band rubber tracks, called "square tires" by some, are one of the outstanding advancements of this war. They may very well prove to be an invaluable aid to both farm and factory transportation when peace comes.



As a noteworthy instance, 700,000 different items of equipment and supplies in varying quantities crammed the convoys that carried American armies to conquest in North Africa—250,000 different items of ordnance; 100,000 different Engineer Corps articles; 68,000 different items of medical supplies and drugs; 10,000 different items for the Signal Corps; 390 different articles of clothing.

Countless hours of planning and figuring, as these statistics suggest, are essential in establishing the types and quantities of items needed . . . amassing them at the assigned embarkation points . . . dividing them strategically among the ships, to minimize the danger of crippling loss of any one item.

Allied superiority in the science of supply is increasingly obvious day by day. To the vital figure work involved, Burroughs adding, calculating, accounting and statistical machines bring a speed and an accuracy indispensable to the magnitude of the undertaking.

BURROUGHS ADDING MACHINE COMPANY, DETROIT, MICH.

Manufacturing for War

The manufacture of aircraft equipment for the Government and the manufacture of Burroughs figuring and accounting equipment for the Army, Navy, U. S. Government and the nation's many war activities, are the vital tasks assigned to Burroughs in the Victory Program.

★

BACK THE ATTACK!

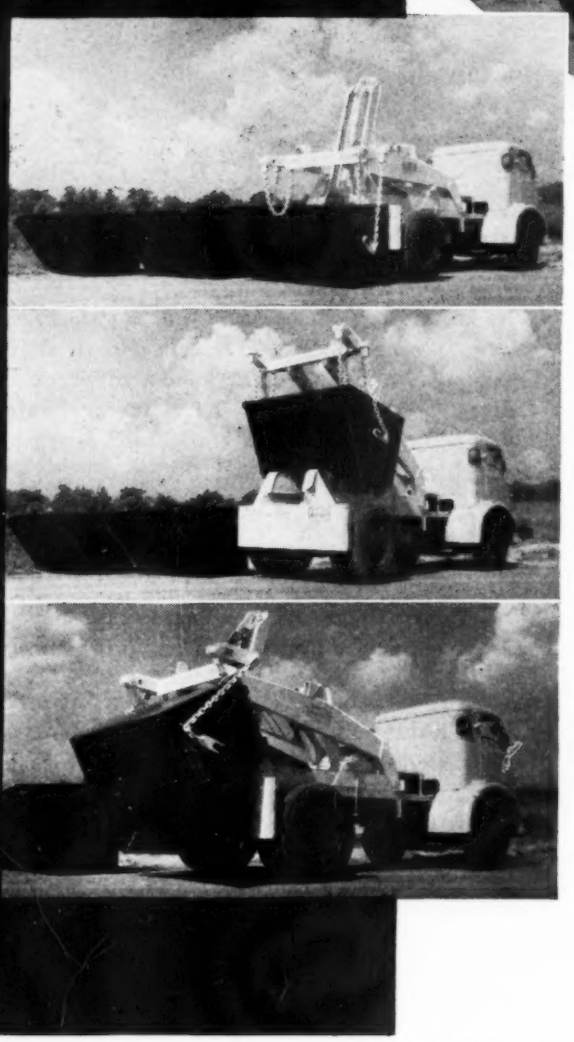
BUY MORE WAR BONDS

★

Burroughs

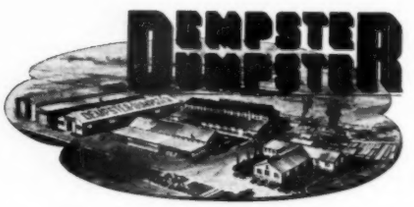
FIGURING, ACCOUNTING AND STATISTICAL MACHINES • NATIONWIDE MAINTENANCE SERVICE • BUSINESS MACHINE SUPPLIES

Lifting 6 TONS is duck soup!



★ Another Dempster Development For Industrial Materials Handling

In hundreds of industrial operations throughout the nation, many of which are essential war plants, the Dempster-Dumpster is handling extremely heavy materials—hoisting, hauling, and dumping loads of almost unbelievable size and weight. Amazing as it may seem, a Model 500 LF Dempster-Dumpster truck unit will hoist any one of several types of Dempster-Dumpster bodies containing a pay load up to 7½ Tons with ease, place it in carrying position, haul it and discharge the load automatically, or set the load down intact, while other bodies, placed at convenient loading points, are being loaded. Other models of less capacity are available for lighter requirements for handling any type of materials . . . bulky, light or heavy . . . waste, unfabricated or finished product. It's simply a matter of adapting the Dempster-Dumpster to your needs . . . with one truck and any number of bodies of various types serving your requirements.



DEMPSTER BROTHERS, INC., 6113 Springdale, Knoxville 17, Tenn.

WE DO THIS TO STEEL

When we want "inside information" about A. S. F. steel castings, we ask a million-volt X-ray camera. Tests that were mere scientific curiosities a decade or so ago are as commonplace to our laboratories today as opening the morning mail. That is why we can make *better* cast-steel armor for tanks and gun mounts. For progress that is pacing the industry, look to America's greatest steelcaster!

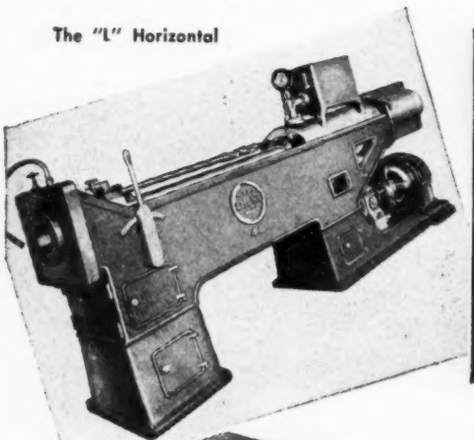
AMERICAN STEEL FOUNDRIES

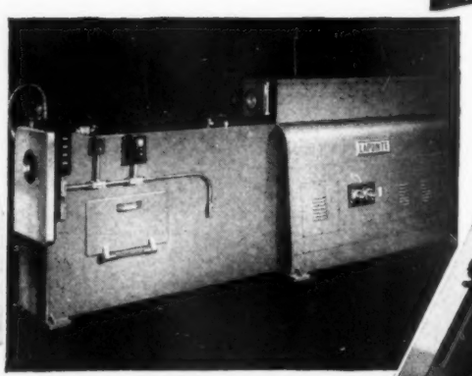
CHICAGO

MINT-MARK OF ⬡ FINE CAST STEEL

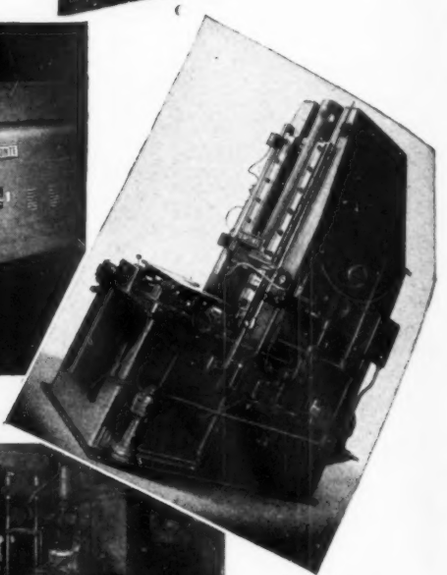
What,— No prizes for pulchritude?

The "L" Horizontal

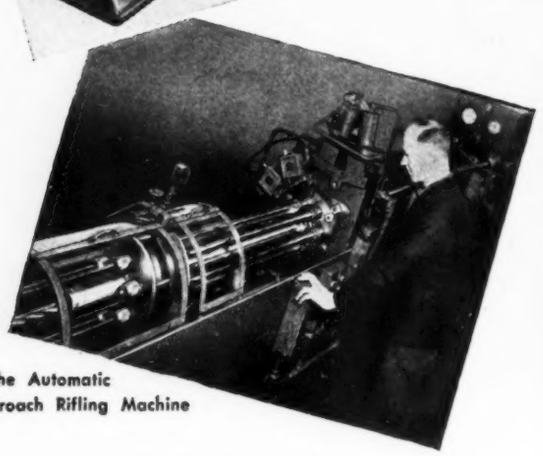




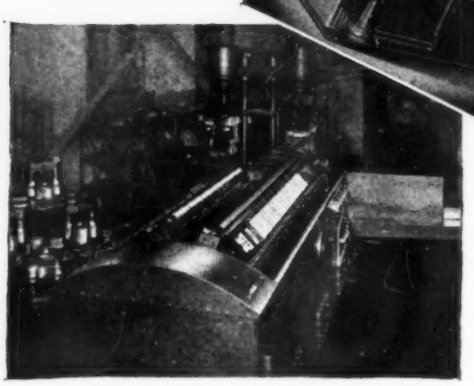
The "HP" Type Horizontal



The Variable Speed Vertical



The Automatic Broach Rifling Machine



The 8-Broach Turret Operated Machine

Maybe they won't win a beauty prize but for downright operational efficiency they are putting a crimp in laggard production and "amateur" spoilage. They are the powerful "belles" of broaching. "Belles" that put other methods of machining to shame for getting there "Fustest with the mostest." They are the answer to the gunner's prayer. They are the line of automatic rifling and breech ring turret broaching machines.

The gun rifling machines, with 5 to 7 broaches and automatic indexing fixtures, cleans out the barrel, sizes up the inside diameter, puts in the riflings, smooths out the outside diameters and polishes up the splines, so fast that it keeps one man humping to keep up with the machine; so accurately that range discrepancies are out. Then there is the turret broaching machine that does a fistful of operations to make American breech rings the envy of the world. Thanks to the Ordnance Department — and broaching engineered principles — these powerful "belles" of broaching put the "Bee" on Benito and the Jap on the jump.

ARMY NAVY

The LAPOINTE Machine Tool Company

HUDSON, MASSACHUSETTS, U. S. A

Freedom CALLING

. . . from field sets in jungles . . . from bombers in the sky . . . from one hundred and thirty-five million fighting, working, determined American souls—at work for Victory.

MILSCO MANUFACTURING is 100% in war production—making gun slings, holsters, scabbards, pack saddles, cantle bags, tank and bomber seats, instrument cases, helmets, and a vast assortment of other leather and metal battle accessories.

BUT WE CAN DO MORE—AND WE WILL DO MORE—for we won't feel satisfied that we are matching the worth of freedom until every productive facility of our plants is working 24 hours a day, every day, every week, every month—for "the inevitable Victory."

Tell us of your needs in leather or metal war equipment, and your inquiry will have complete and immediate attention.

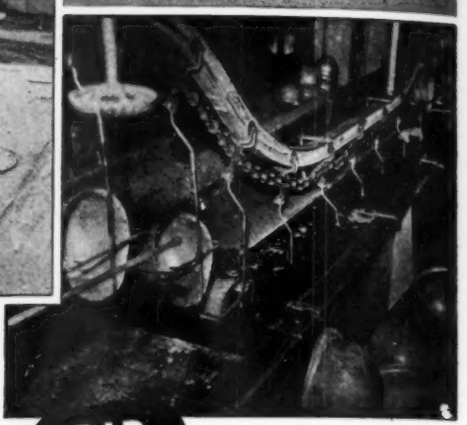
MILSCO MANUFACTURING CO.

MILWAUKEE WISCONSIN

RUST ?

No Problem if you use...

DEOXIDINE



DEOXIDINE is a time tested phosphoric acid metal cleaner that removes rust chemically from pits as well as from the surface and at the same time destroys or neutralizes rust producers. Deoxidine also removes oil, light oxides, annealing scale, etc., eliminating in many operations the necessity for a separate pickling.

Deoxidine may be applied by dipping, spraying or brushing. There are various types of Deoxidine adapted to the several methods of application and to the cleaning of surfaces with varying amounts of rust and oil.

Deoxidine which introduced the new principle in metal cleaning as long ago as 1916, is a proved material and standard practice.

Write for Service Data Sheet.

Manufacturers of Inhibitors & Metal Working Chemicals

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP **PENNA.**

Note: West Coast Plants may address inquiries and orders for prompt delivery to, Leon Finch, Ltd., 728 East 59th St., Los Angeles, Calif.

American Chemical Paint Company, Ambler, Pa.

Please send me general Technical Service Data Sheets on

☐ Deoxidine

Name _____

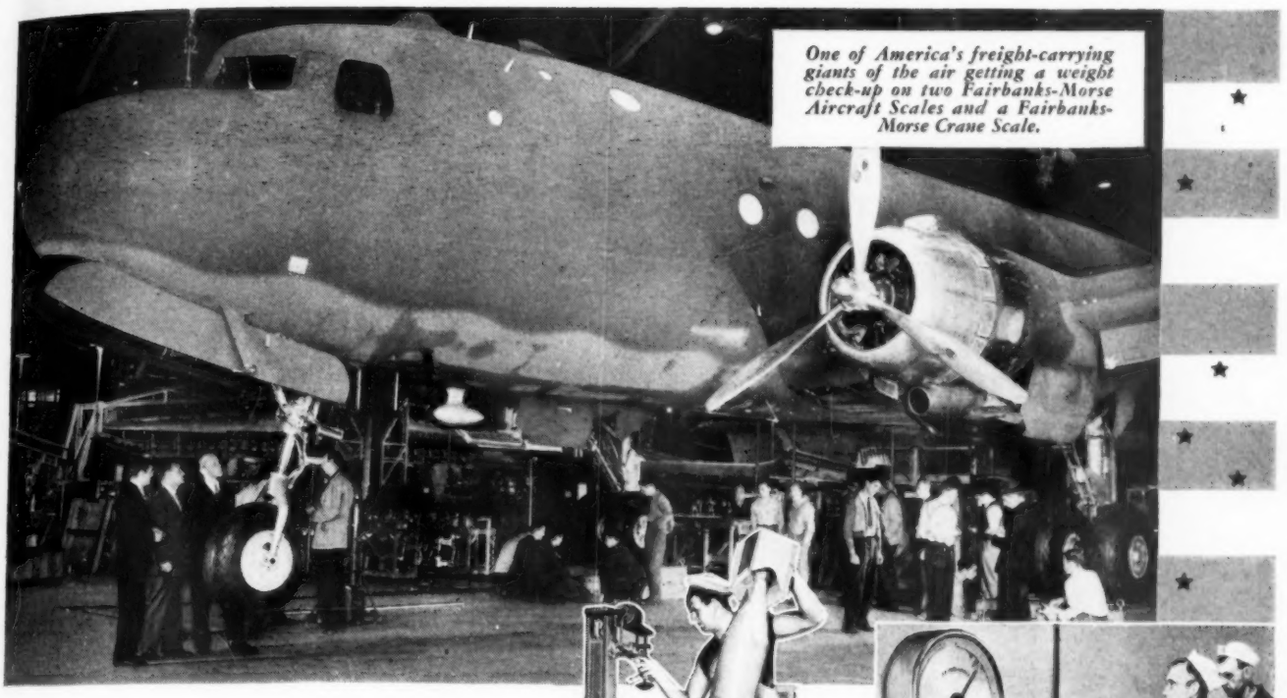
Title _____

Company _____

Address _____

H-10

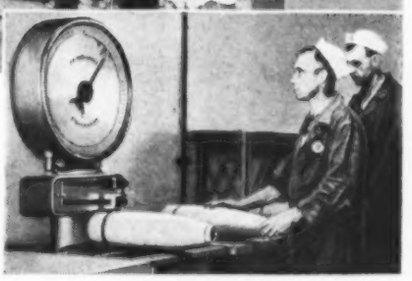
Fairbanks-Morse Scales in Warwork



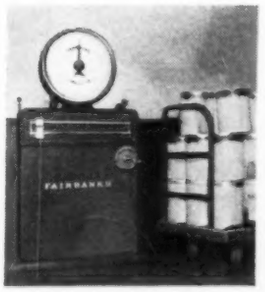
One of America's freight-carrying giants of the air getting a weight check-up on two Fairbanks-Morse Aircraft Scales and a Fairbanks-Morse Crane Scale.

• WARWORK means *weigh-work* for Fairbanks-Morse Scales. They're weighing munitions . . . food . . . chemicals . . . tanks . . . aircraft . . . shells . . . just about everything, in fact. They are weighing at speeds which human hands can't match. They're weighing with accuracy that human eyes can't equal. They're working in endless shifts that human stamina can't endure. They're helping to speed up America's war effort on the production front, for Fairbanks-Morse Scales are "at home" on the production front, in peace or in war. Fairbanks, Morse & Co., Fairbanks-Morse Building, Chicago, Illinois.

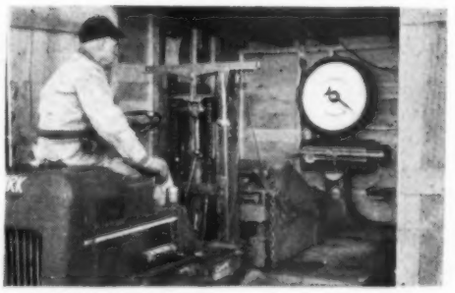
Weighing an "egg" for the Axis.



Correct weight for accurate gunnery.



Frozen eggs—NOT for the Axis!



Weighing charging materials at iron works furnace.

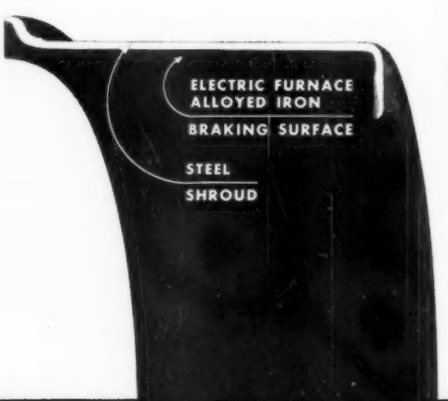
FAIRBANKS-MORSE

DIESEL ENGINES
PUMPS
MOTORS
GENERATORS
WATER SYSTEMS
SCALES
STOKERS
FARM EQUIPMENT
RAILROAD EQUIPMENT

Scales

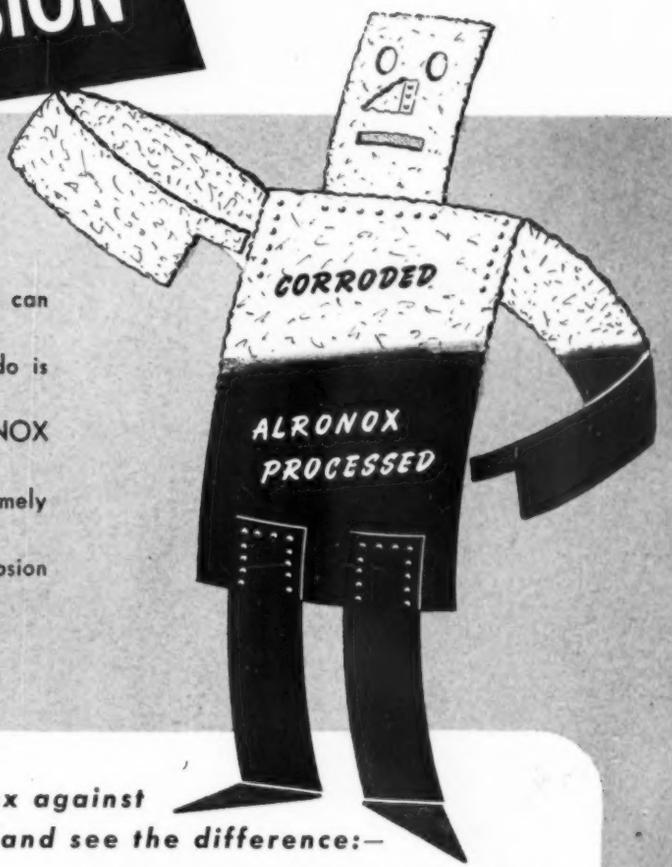
BUY WAR BONDS

The tough, light weight, explosion-proof Centrifuse Brake Drums used on many American 4-engined bombers have withstood tremendous shock and terrific heat under extreme operating conditions. Never has a failure been reported. All reports prove maximum brake capacity with minimum deterioration from heat of tire, wheel and brake. These highly satisfactory results also hold true on other bombers, pursuit ships, trainers, scout cars, trucks and other armored vehicles equipped with Centrifuse —the world's greatest brake drums.



CENTRIFUGAL FUSING COMPANY
LANSING, MICHIGAN
DIVISION OF CAMPBELL, WYANT & CANNON FOUNDRY CO.

MAKE WAR ON ZINC CORROSION



Corrosion of zinc or zinc alloy surfaces can now be prevented! All you have to do is treat these surfaces by the ALRONOX PROCESS,— an immersion method. Extremely simple, it produces an even, black, corrosion resistant coating.

Check these facts on Alronox against what other processes offer and see the difference:—

- Non-electrolytic
- Low temperature — 212° F.
- Fast production — 7 minute cycle.
- Simple equipment.
- No elaborate controls.
- Even, dense black surface.
- Low reflectivity.
- Adaptable to all zinc and die-cast surfaces.
- 200-300 hours salt spray rating on .0002 zinc plate over steel without after coating (no rust).
- Excellent base for organic coatings.
- High weather and humidity resistance.
- Can not chip or peel.
- Low cost.

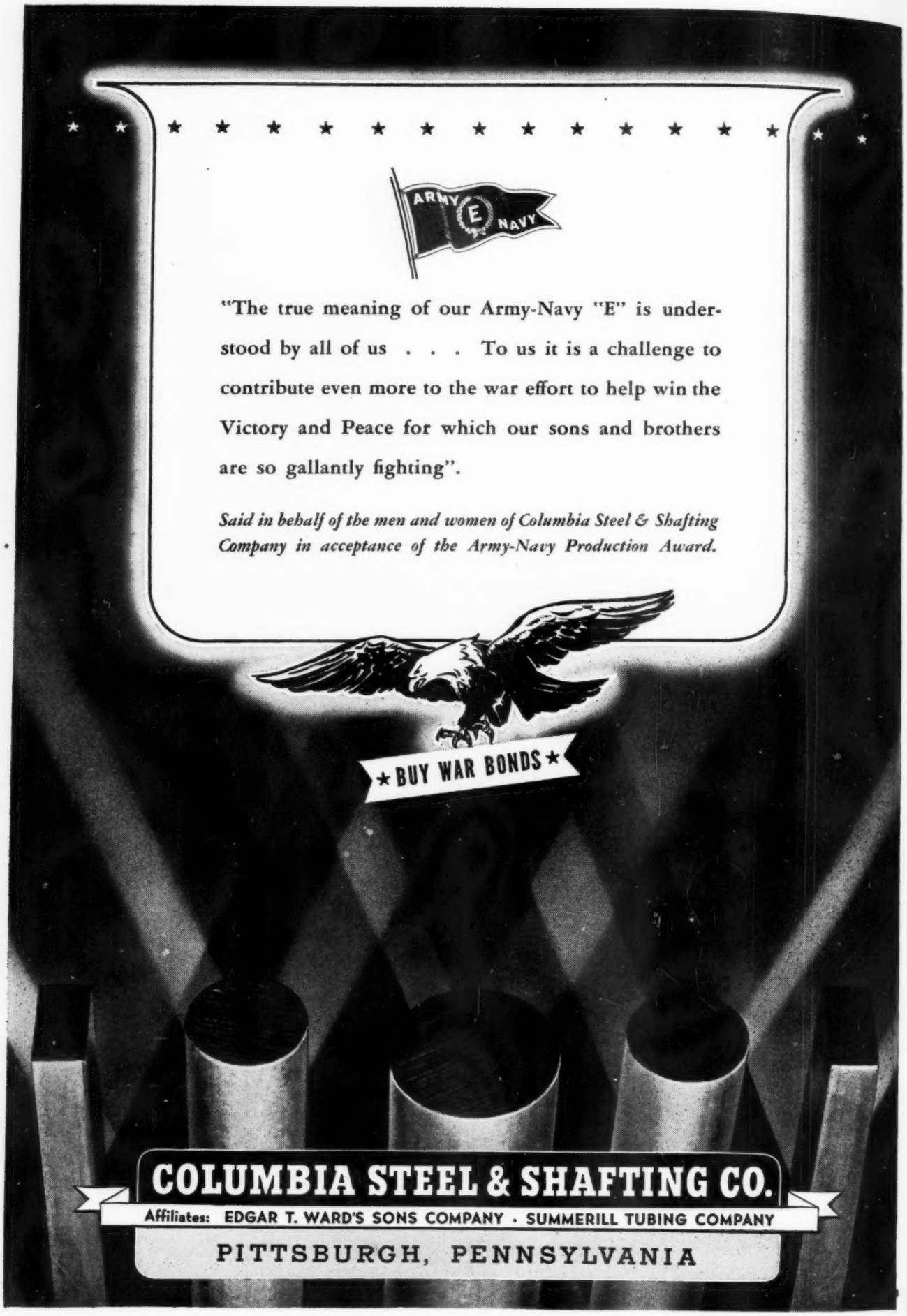
EXPERIENCED ENGINEERS IMMEDIATELY AVAILABLE FOR CONSULTATION. SAMPLES FINISHED WITHOUT CHARGE. *WRITE . . . WIRE . . . PHONE*

ALROSE CHEMICAL CO.

PROVIDENCE, R. I., U. S. A., TEL. WILLIAMS 3000-3001

ALRONOX PROCESS

A Black Protective Finish on Zinc or Zinc Alloy


ARMY E NAVY
"The true meaning of our Army-Navy "E" is understood by all of us . . . To us it is a challenge to contribute even more to the war effort to help win the Victory and Peace for which our sons and brothers are so gallantly fighting".
Said in behalf of the men and women of Columbia Steel & Shafting Company in acceptance of the Army-Navy Production Award.
★ BUY WAR BONDS ★
COLUMBIA STEEL & SHAFTING CO.
Affiliates: EDGAR T. WARD'S SONS COMPANY · SUMMERILL TUBING COMPANY
PITTSBURGH, PENNSYLVANIA

The Crackle that Grew to a Roar!

Remember the crackling of the aluminum foil that was used to package and protect so many products in daily use? You don't hear it any more, do you? It's gone . . . until the boys come marching home.

Long before Pearl Harbor, Reynolds—the world's largest aluminum foil producer—foresaw a shortage of aluminum in this country. So we put all of our foil plants on a war basis . . . all of our precision experience in rolling light metal into the war effort. We staked all our resources on Bauxite mines and tremendous new plants to convert the ore into finished aluminum.

When war came, America had a great new source of aluminum ready and rolling.

Today, with hundreds of millions of pounds of finished metal already produced, Reynolds Aluminum flies into battle in virtually every American plane.

Yes, the crackle of Reynolds Aluminum foil has become a roar heard 'round the world.

REYNOLDS METALS COMPANY • General Offices, Richmond, Va. • Parts Division, Louisville, Ky. • 37 PLANTS IN 13 STATES

Reynolds "Fighting Foil" . . . Bodyguard for Bullets!

.30 caliber cartridges first see the light of day on the battle front, as a link belt of 100 is removed from its protective Reynolds casing.

CORRODED BULLETS JAM GUNS! That's why Reynolds Metals "invasion-proof" packaging for .30 caliber aircraft ammunition is, today, serving on every fighting front—protecting cartridges against the invasion of dust, grit and moisture. It's air-tight, water-tight...giving *really armor-clad protection without the use of steel.*

This new wartime packaging is a solid sheet of metal foil laminated to varied processed materials and securely heat sealed. Truly "fighting foil"... developed by Reynolds...produced by Reynolds...and "battle-tested" on every worldwide fighting front, where it is now protecting foods, drugs, ammunition and supplies under every wartime condition.

Let Reynolds apply their extensive packaging research and experience to your own needs. Representatives available throughout the country.

Reynolds Battle-Tested Material Meets These Army-Navy Requirements

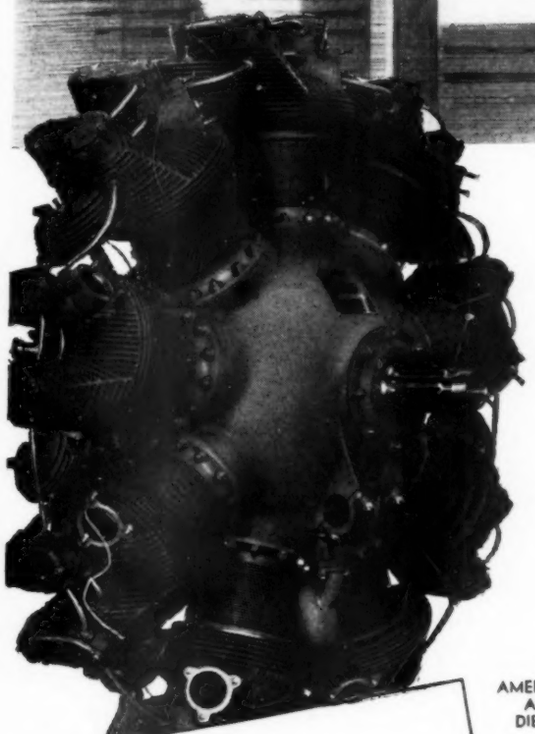
1 *Positive Protection Against Moisture-Vapor Transmission.*
2 *Immersion-Proof. Keeps Water Out!*
3 *Protection Against Insect Infestation, Odors and Light.*
4 *Substantial Saving in Tin, Steel and Other Strategic Materials.*
5 *Saving in Space, Especially Shipment and Storage of Empties.*
6 *Saving in Weight.*
7 *Serviceability Under Export Conditions.*

100 cartridges to a carton—12 cartons to a case. 1200 rounds all Reynolds protected!

Ammunition arrives at base. Across oceans—through every element—as originally packed.

REYNOLDS ALUMINUM
OUT OF THE GROUND INTO THE SKY

REYNOLDS METALS COMPANY • FOIL DIVISION
GENERAL OFFICES • RICHMOND, VIRGINIA
America's Great New Source of Aluminum



TOMORROW THEY WILL FLY!

Today Bill and Jane and Mother look to the skyways! Dad may already ride the airlines. Perhaps he holds his pilot's certificate, too. But tomorrow they all will fly. *Family* flying must be *safe* flying and *safe* flying must be *fire-safe*. That's why the Guiberson air-cooled radial diesel engine, using fuel that will not burn even when exposed to flame, is the power plant for the family plane of tomorrow. Guiberson powered equipment is now hitting the Axis in distant corners of the world. It is ready today to serve American industry with fire-safe power on land, on sea and in the air!

AMERICA'S RADIAL AIR-COOLED DIESEL ENGINE

- No Fire Hazard
- Lower Fuel Consumption
- Increased Cruising Range
- Greater Stamina
- Dependable Operation
- Instant Response to the Throttle
- No Ignition System
- Lower Cost of Fuel
- Constant Torque at All Speeds
- No Radio Interference

SAFER THAN SORRY — BETTER BE GUIBERSON

ESTABLISHED 1919

Guiberson U.S.A.

THE GUIBERSON DIESEL ENGINE COMPANY
THE GUIBERSON CORPORATION
Aircraft and Heater Division
DALLAS, TEXAS — CHICAGO, ILLINOIS

© 1943 Great American Industries, Inc., Meriden, Conn.

Any way you figure it—if your trucks have special jobs to do they should be *special trucks*, engineered from bumper to bumper for their particular assignment. Such motor trucks do more useful work per day, at a lower cost, and with longer life.

The Ward LaFrance name on your trucks stands for equipment specially created by a manufacturer of highest standing, for the job it is intended to do.

Many users of stock model vehicles will be surprised to learn about the advantages which could be obtained from a specially engineered and built Ward LaFrance fleet. Investigate *now* — it's none too soon.

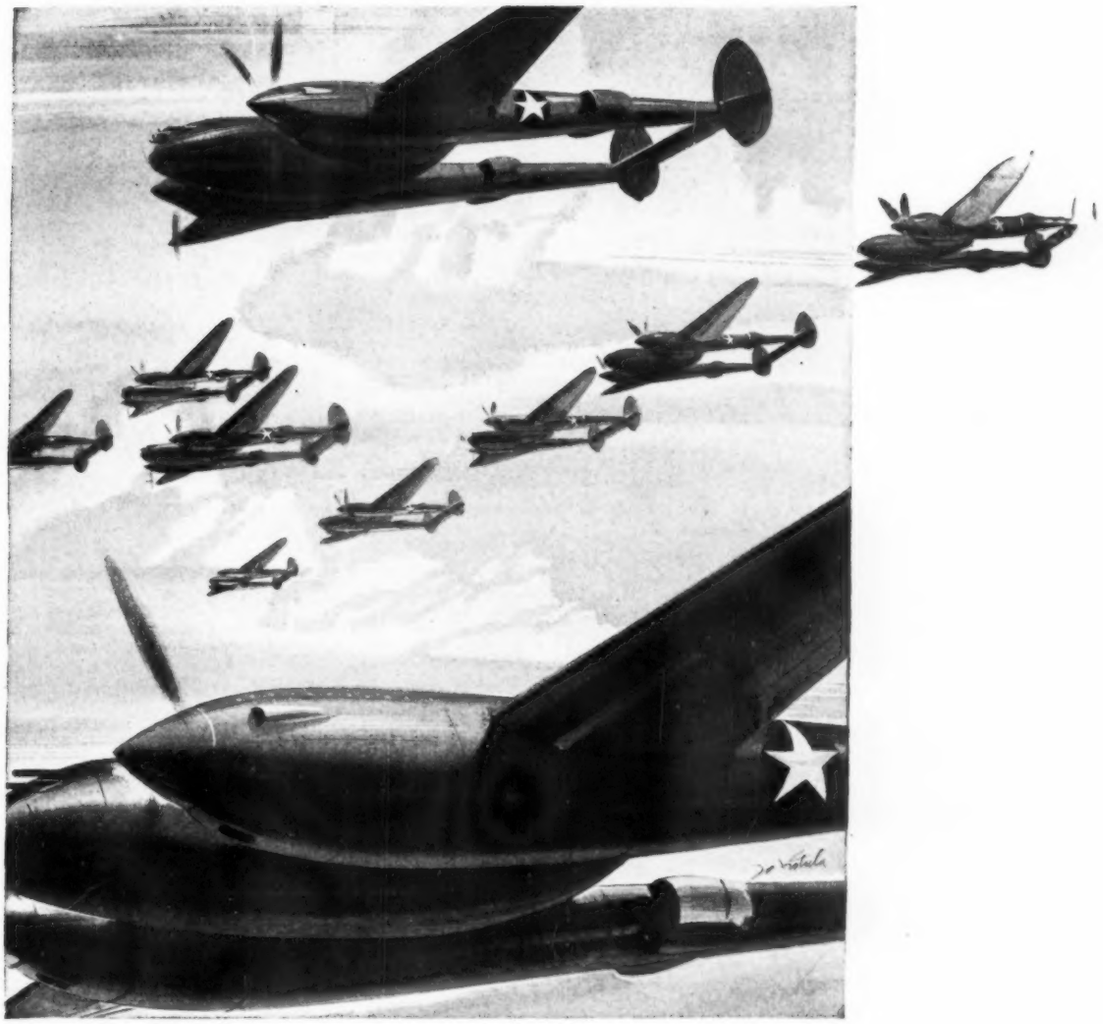
Heavy Wrecker M1

● A prime example of trucks built for the job, are the heavy wreckers being built by Ward LaFrance for the Army. They are used for tank recovery work and other recovery operations.

WARD LaFRANCE TRUCK DIVISION

ELMIRA, NEW YORK

GAI GREAT AMERICAN INDUSTRIES INC.



MISSION ACCOMPLISHED

. . . and bearings played their part

HAVE you ever wondered how airplane engines drive warplanes through the air at better than 400 miles per hour — without burning themselves out? Or, how aircraft instruments can be so sensitive that men fly unerringly to a speck in the ocean, and drop bombs with such deadly accuracy?

The free-rolling motion of anti-friction bearings makes these achievements possible. Such bearings reduce friction to the vanishing point...keep mechanisms cool...postpone wear and maintain precise location of parts.

New Departure ball bearings are used by the millions in American war planes. In fact, New Departure has a major responsibility in the whole ball bearing war production program.

NEW DEPARTURE *ball bearings — as near perfection as engineering science can make them — help to keep 'em . . . flying . . . rolling . . . firing . . . winning.*

Nothing rolls like a ball

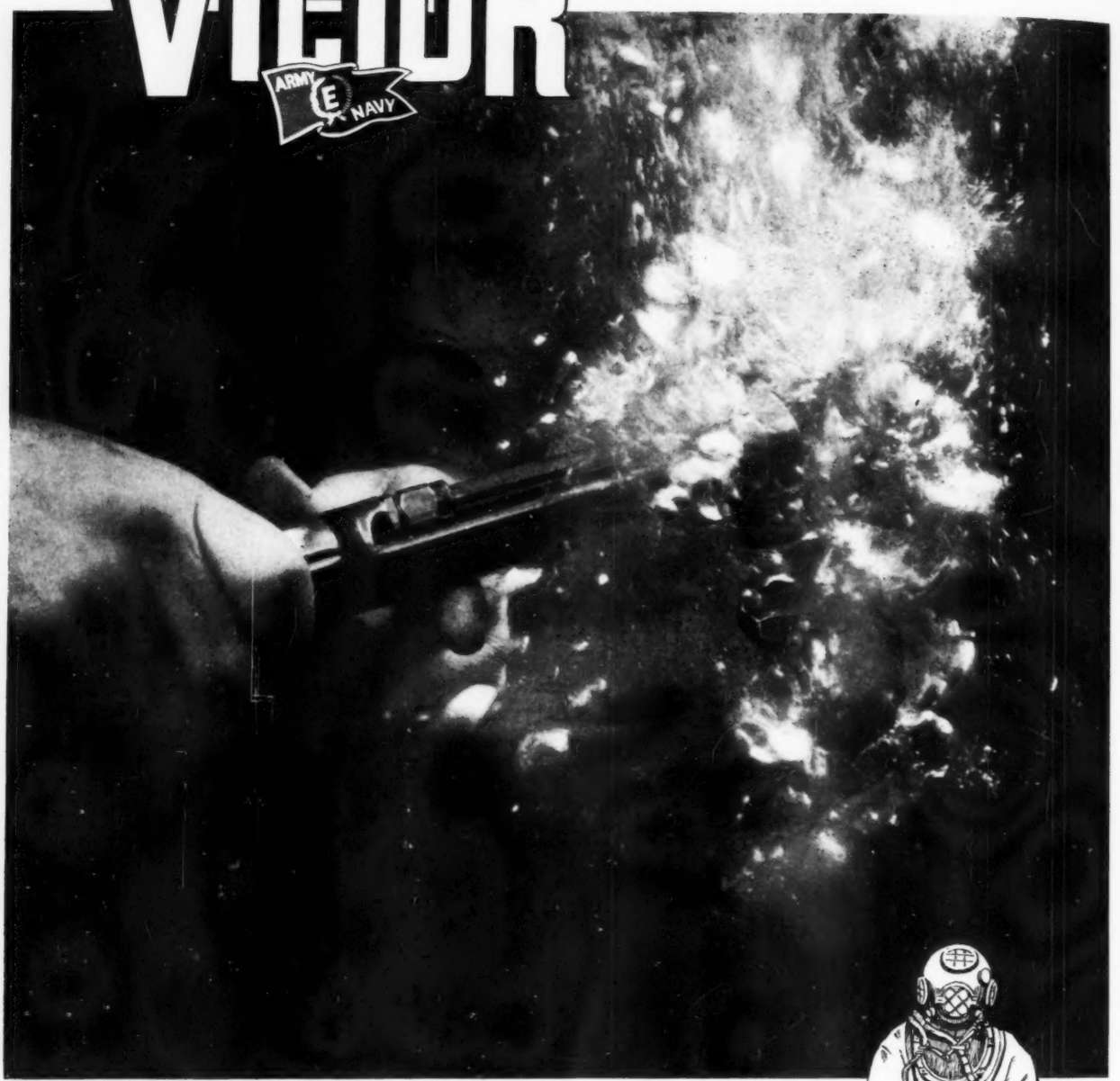
New Departure

THE FORGED STEEL BEARING

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

VICTOR

ARMY E NAVY

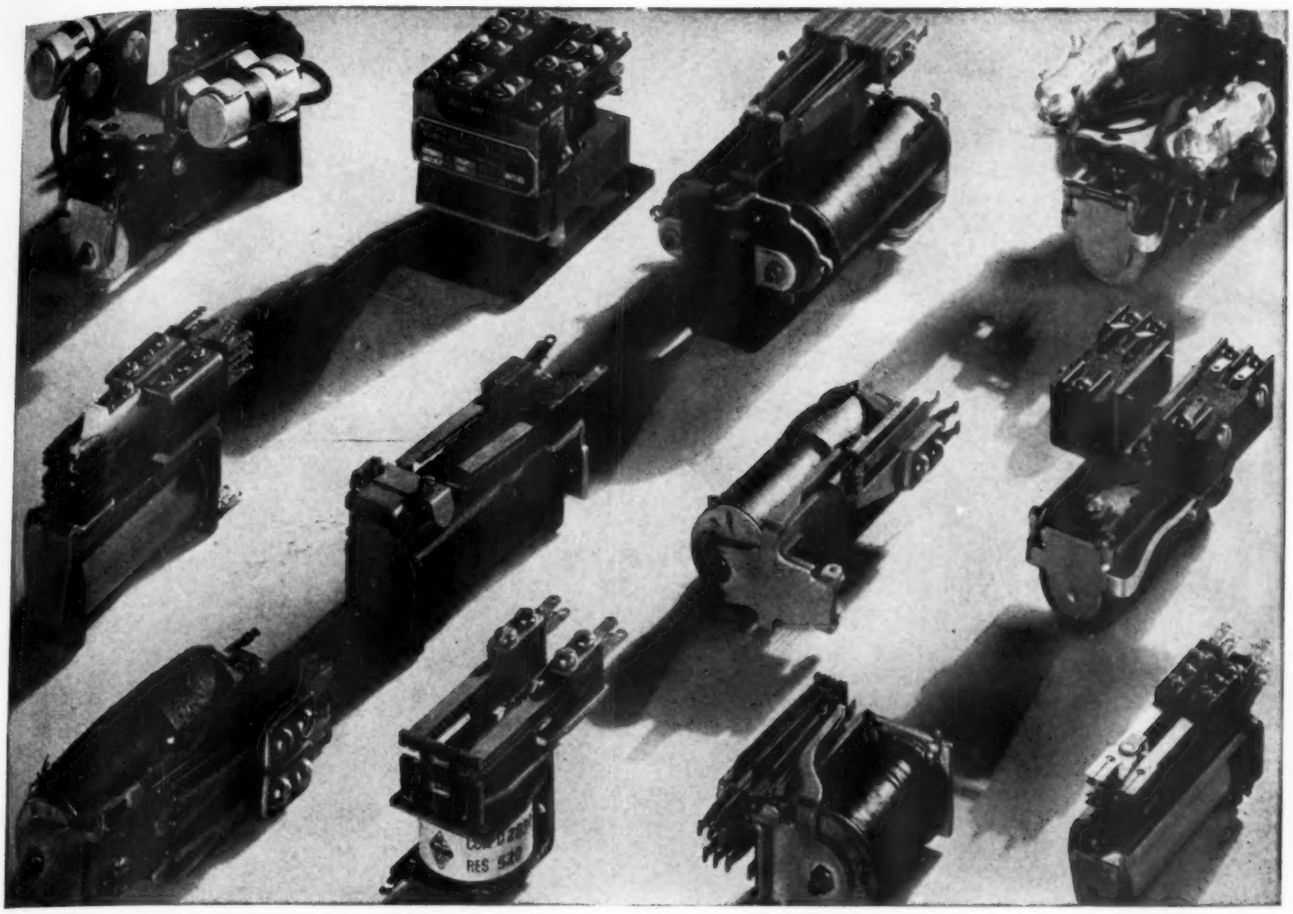


Actual photograph of underwater cutting

Whether it be an underwater cutting torch which helped to salvage the damage of a treacherous attack at Pearl Harbor or a welding and cutting unit at an important Army air base or aboard ship, there is one primary qualification such equipment must possess—DEPENDABILITY.

Victor equipment is dependable in operation and the sturdiness of its construction greatly lessens repair and maintenance problems.

VICTOR EQUIPMENT COMPANY
844 FOLSOM STREET · SAN FRANCISCO



FOR EVERY ELECTRICAL CONTROL PROBLEM THERE'S AN AUTOMATIC ELECTRIC RELAY

Automatic Electric Relays and other control devices can be found in countless units of equipment used by the armed forces—are being used in scores of ways on the production front.

The Automatic Electric line includes a complete range of relays, stepping switches, lever keys, and other control devices. They are products of proved dependability—developed by the same engineering technique that created the dial telephone system—the world's most outstanding example of the application of electrical control to a basic need.

Behind the dependability, long life, and precise performance of Automatic Electric control devices—is a half century of experience in dealing with remote-control problems of all types. Consequently, Automatic Electric engineers are well equipped to lend valuable assistance to the armed forces and the makers of many war products.

FREE to those requesting it is the Automatic Electric catalog of remote-control apparatus. It's the most complete handbook on the subject ever published. Between its pages are basic types to fit any conditions. Write for your copy.

AMERICAN AUTOMATIC ELECTRIC SALES COMPANY
1033 W. Van Buren Street, Chicago, Illinois

Relays
AND OTHER CONTROL DEVICES
by AUTOMATIC ELECTRIC

Preparing Fuze Parts for Zinc Plating

A typical example of a Specialized cleaning job . . . . Process developed exclusively by CLEPO Laboratories

CLEPO CLEANING COMPOUNDS

Before Cleaning

FIRST Step in CLEPO Cleaning Process

SECOND Step in CLEPO Cleaning Process

THIRD and Last Step in CLEPO Cleaning Process

Fuze parts are typical of steel parts covered with scale and oil which must be cleaned oxide-free and water-break-free prior to zinc or cadmium plating.

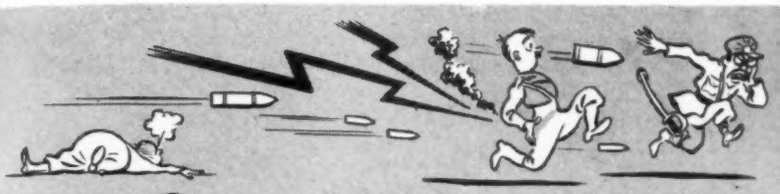
This 3-step method is readily adapted to either hand cleaning or automatic cleaning cycles requiring a maximum of 3-minute cleaning time.

If you have a problem of a similar nature, wire us, and we will put you in immediate contact with our local Clepo service man.

Buy War Bonds and Stamps

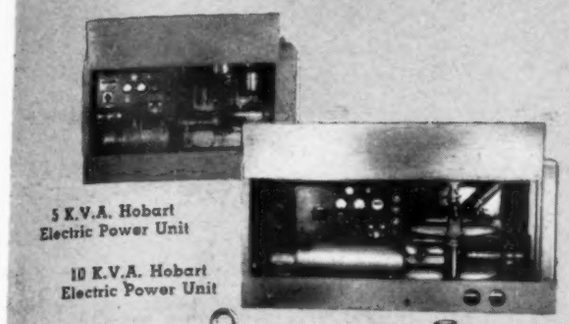
FREDERICK GUMM Chemical Company

538 FOREST STREET, KEARNY, N. J.



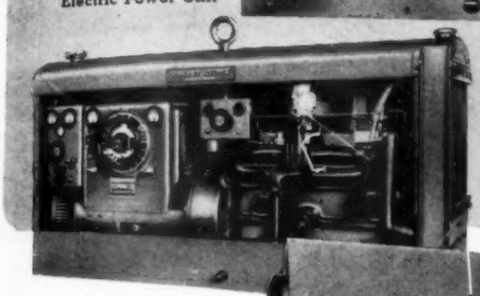
Look Out Hitler and Hirohito...

THERE'S MORE POWER COMIN' UP!

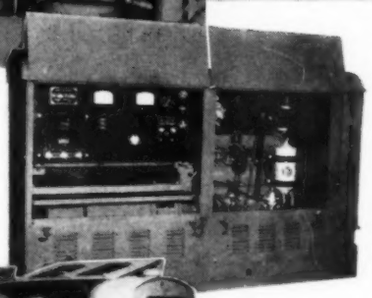


5 K.V.A. Hobart Electric Power Unit

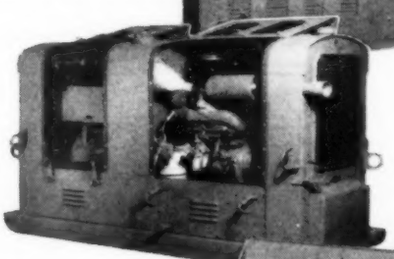
10 K.V.A. Hobart Electric Power Unit



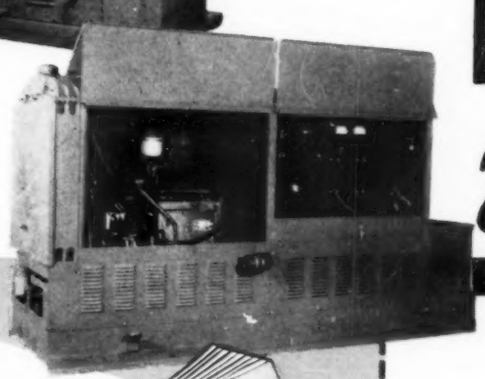
Combination Gas Drive Welder and 3 K.W. generator



25 K.V.A. Hobart Electric Power Unit



Hobart 3 K.V.A. Electric Power Unit



35 K.V.A. Hobart Electric Power Unit

ARMY NAVY — Awarded to Hobart Brothers for Excellence in War Production

This Catalog — is yours for the asking. Send Coupon.

With fighting forces everywhere; with supply, maintenance and base operations, Hobart Power has gone along. They're tops for electric gun-firing; as a power source for portable machine shops, water purification, oil reclaiming; as instant current for auxiliary lighting appliances, motors, radio transmitters, telephone and teletype communications. Hobart's famous welding generators are working overtime. There's hardly a power problem anywhere, anytime, that can't be met with a Hobart outfit. New uses are being discovered daily.

HOBART BROS., BOX AO-113, TROY, OHIO

HOBART ELECTRIC POWER UNITS

HOBART BROS., BOX AO-113, TROY, OHIO

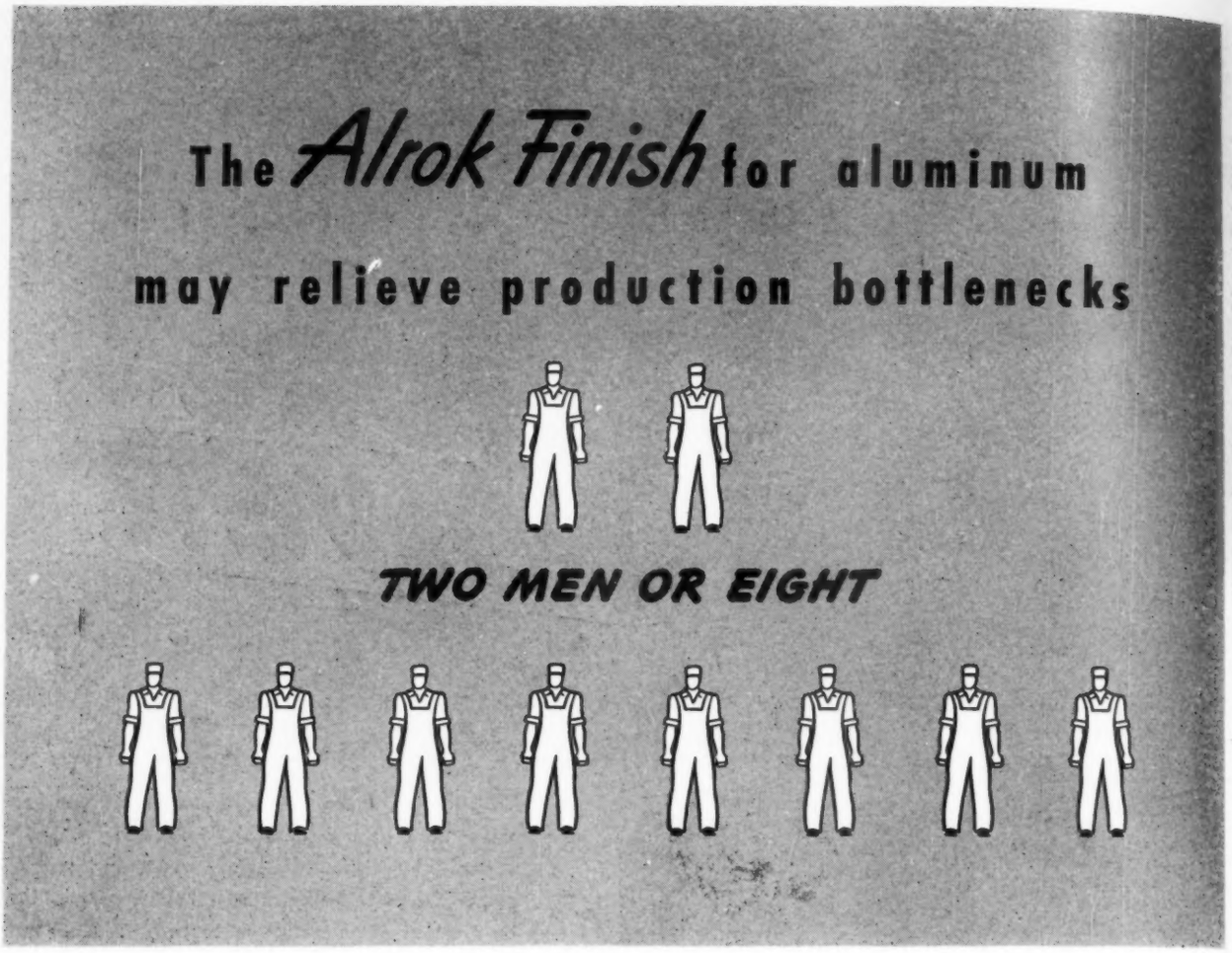
Send information on items checked:

- ☐ Electric Power Units
- ☐ Electric Generators
- ☐ Electric Drive Welders
- ☐ Gas Drive Welders
- ☐ Free Catalog on complete Hobart Line

NAME _____

ADDRESS _____

CITY _____ STATE _____



Alcoa-research developed the Alrok* finish for use on aluminum surfaces that are to be painted. It has proved completely adequate for many parts. It is quite possible that this chemically-applied finish can be satisfactorily substituted in many places where the more expensive, time-consuming electrolytic finishes are now specified.

Note the savings possible where the Alrok finish is employed: In one plant, two men finish 800 pounds of small parts per hour by the Alrok process, and 100% inspection is not necessary. It takes eight men to finish the same quantity of parts by the electrolytic process.

Bear in mind that, for the use made of these parts, both jobs are equally acceptable. Only one fourth the number of men, and no electrical generators, are required for the former finishing job. The Alrok finish certainly deserves consideration for many parts on which the electrolytic finish is now specified.

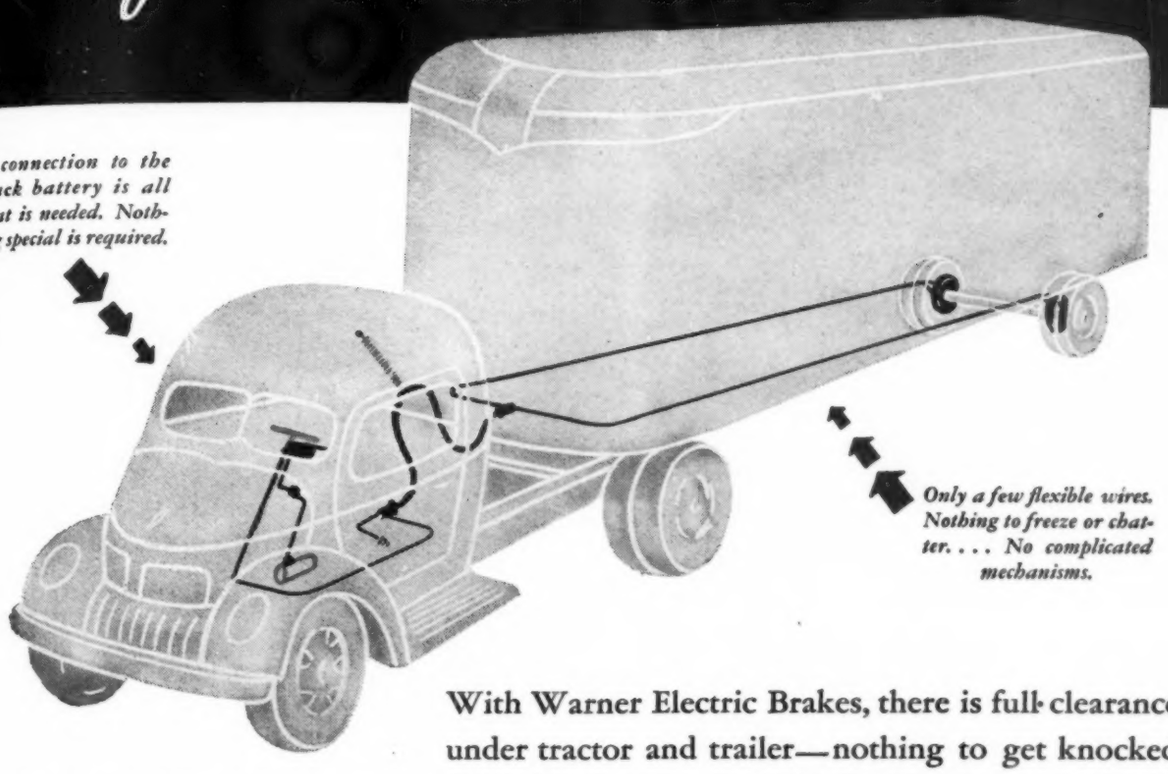
There's an approved Government specification covering the Alrok finish for certain purposes. ALUMINUM COMPANY OF AMERICA, 2137 Gulf Bldg., Pittsburgh, Pa.

Patented process

ALCOA ALUMINUM

NO OTHER BRAKE EQUALS THE WARNER ELECTRIC BRAKE *for* SIMPLICITY

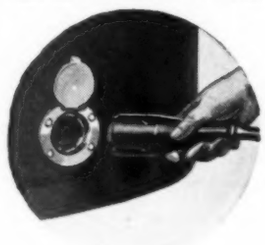
A connection to the truck battery is all that is needed. Nothing special is required.



Only a few flexible wires. Nothing to freeze or chatter. . . . No complicated mechanisms.

With Warner Electric Brakes, there is full clearance under tractor and trailer—nothing to get knocked off or leak—no exposed braking equipment—no rods to rattle—no tubing to split—no condensation to freeze. Warner Electric Brakes require only a wire to each wheel and will operate under water without short circuiting. Minimum maintenance cost.

PLUGS IN AND OUT LIKE A RADIO



The plug-in cable provides current for brakes, tail light, stop light and running lights.

Right now, the needs of our armed forces come first! However, if you are on the "essential" list we can supply you with brakes.

WARNER
ELECTRIC BRAKES

WARNER ELECTRIC BRAKE MANUFACTURING COMPANY • BELOIT, WISCONSIN

On KENWORTH *Army Wreckers,* COMPAR-*lined hose stands the gaff*

ARMY wreckers built by Kenworth Motor Truck Corporation take tough terrain in their stride—just as the Resistoflex fuel lines on the engines take constant flexing and exposure to all kinds of gasoline.

For the hose has an inner surface of COMPAR, the unique elastic plastic that is glass-smooth though soft and flexible, completely impervious to gasoline—leaded or unleaded, straight or containing a high percentage of aromatics. COMPAR is non-swelling, non-sloughing, assuring free, full flow of fuel under the most severe conditions.

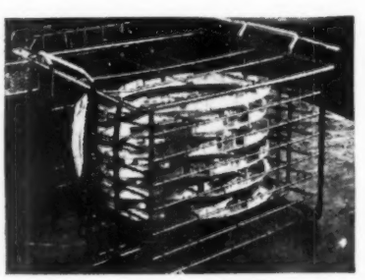
And the construction of Resistoflex hose provides maximum strength, while retaining the extreme toughness and flexibility of the COMPAR inner core. Resistoflex hose has exceptional resistance to shock loads, vibration and flexing.

This is just one of the many time-tested applications of Resistoflex hose on military trucks and similar equipment. For full details on the sizes and characteristics of hose and hose assemblies, write for the Resistoflex Industrial Catalog.

BASKET COATING PROTECTS PACKARD PARTS

Highly polished parts for Rolls-Royce aircraft engines move safely through the machining departments at the Packard plant in wire baskets coated with COMPAR—the *same* elastic plastic that gives Resistoflex hose its unique qualities.

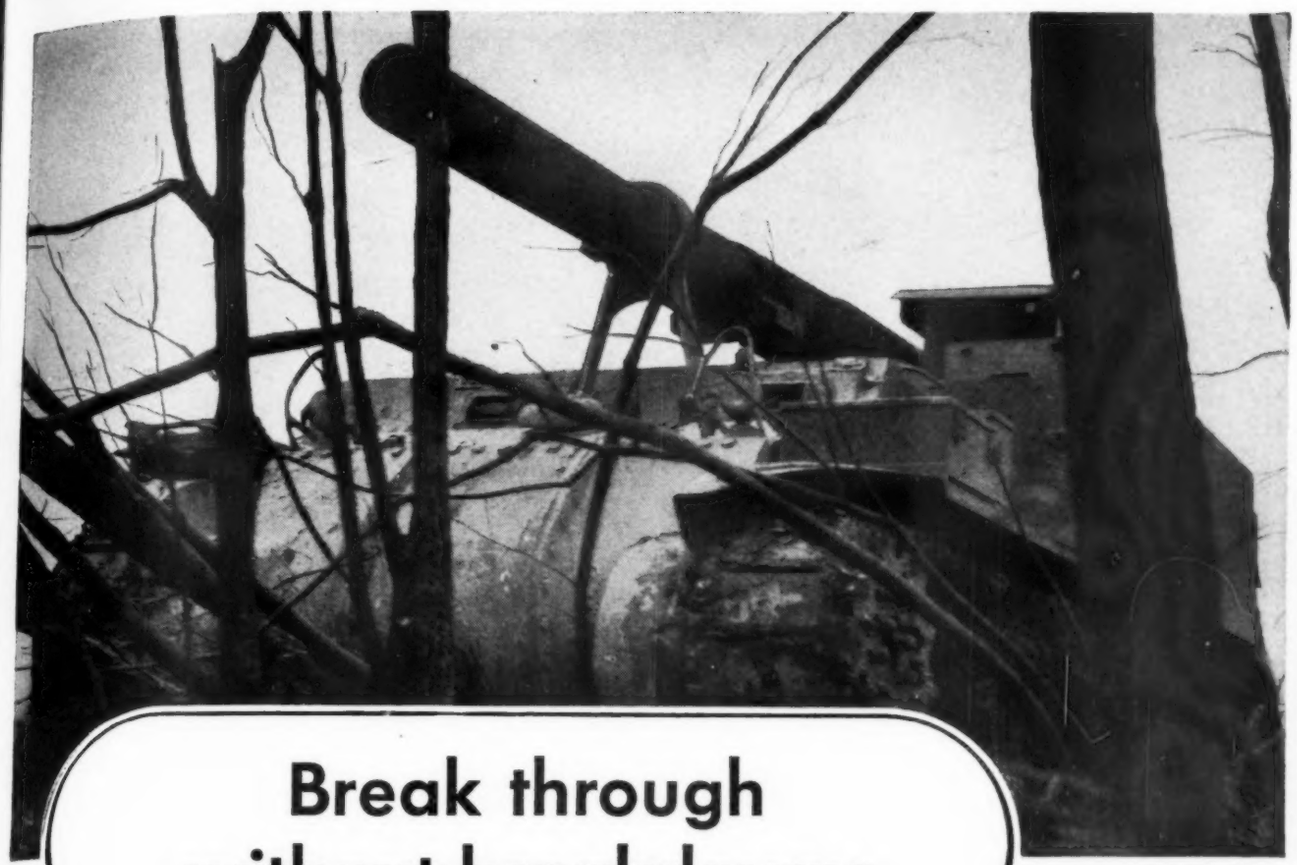
Parts can be degreased right in the baskets, for COMPAR is immune both to oil and to degreasing solvents. Supplied by Resistoflex Corporation in solution form, the coating is easily applied in the user's plant. Write for further information.



RESISTOFLEX

HOSE AND HOSE ASSEMBLIES FOR HYDRAULIC OILS AND VACUUM, FUELS AND LUBRICANTS, ORGANIC SOLVENTS, PAINTS AND LACQUERS, THINNERS, REFRIGERANT, NATURAL AND MANUFACTURED GASES—LABORATORY TUBING—DIPPED AND MOLDED MECHANICAL GOODS—COATINGS, SOLUTIONS AND PROTECTIVE CLOTHING

RESISTOFLEX CORPORATION, BELLEVILLE, NEW JERSEY



Break through without breakdowns

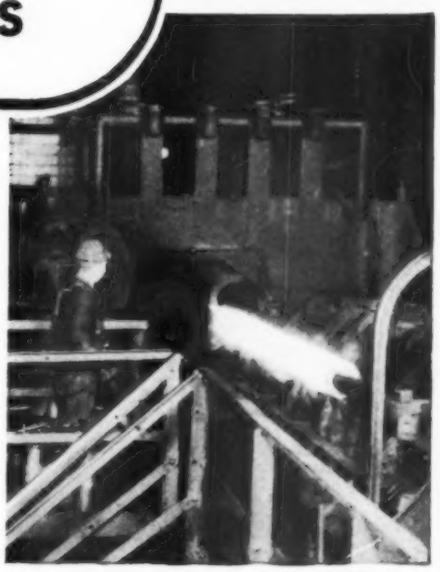
THE big tank busters lived up to their name. Slogging along under enemy gun-fire, over the rocks, through the woods—they completed their assignments quickly, surely, as the men who designed them knew they must.

Construction engineers, building for this sort of rugged strength and trouble-free operation, insure the performance of many vital parts by specifying seamless alloy steel tubing.

Pierced from solid billets of alloy steel, seamless alloy tubing makes for strong, rigid construction, relatively light weight, resistance to corrosion, heat and abrasion. It withstands impact, shock and fatigue. In axles, frames, housings, torque tubes and bearings, tubular alloy steel stands up through long service on all war fronts.

Pre-tested under every imaginable condition of service, Tubular Alloy Steel Corporation products went to war with the backing of 50 years of experience. Our contribution to the war effort is centered on our one job, producing the finest alloy steel tubing that advanced metallurgical research and up-to-date improvements in materials, methods and processes make possible.

Tubular Alloy Steel Corporation makes all sizes of tubes from ¼ inch to 8⅝ inches in the current ranges of alloys, in the customary wall-thicknesses. If you are striving to speed production on essential war equipment, write for complete information on Tubular Alloy Steel products.



Piercing a billet of steel by the seamless process, the only method of tube manufacture that assures uniform wall strength, meets rigid U. S. Government specifications.

★ *BACK THE ATTACK . . . WITH WAR BONDS* ★

The newest name in alloy tubing

TUBULAR ALLOY STEEL CORPORATION

Gary, Indiana

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Export Company, New York

UNITED STATES STEEL

Sound and Furious

Rugged bodies and wrathful determination—powerful aircraft willing and able . . . to win the freedom to live in the American tradition—these are the tools fiercely used over all the world's battlefronts.

Our own job is to supply rugged structural, and sensitive control parts for the planes that are driving back the forces of inhuman aggression.

The men and women of General Aviation and its associate companies work round the clock in this service of supply—so that the war will end soon, and that free Americans will again pursue their self-determined ways.

General Aviation Equipment Co., Inc., Ashley and Wilkes-Barre, Pennsylvania, U. S. A.

General Aviation Equipment

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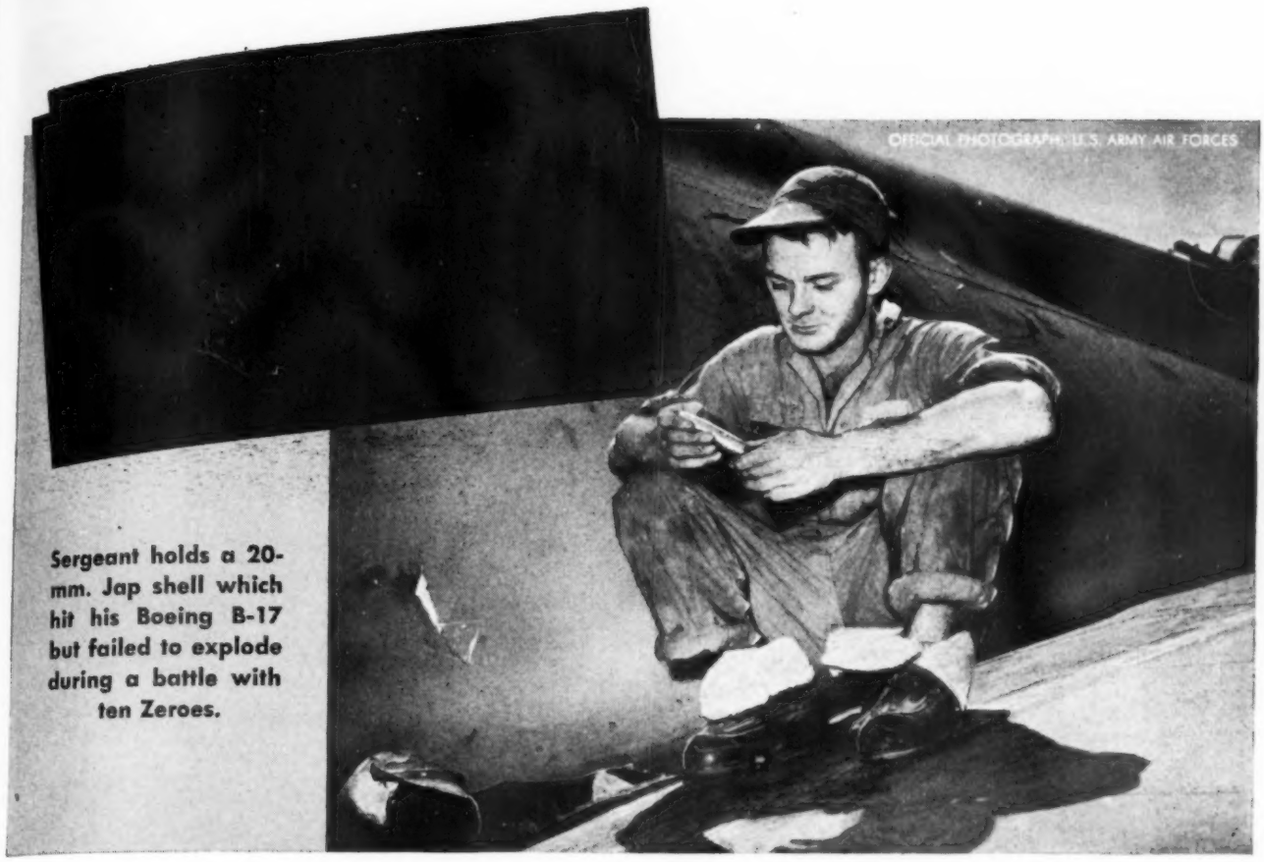

Sergeant holds a 20-mm. Jap shell which hit his Boeing B-17 but failed to explode during a battle with ten Zeroes.

Had the Jap inspectors who passed this 20-millimeter shell done their full duty, this U. S. plane and the flyer holding the shell might have crashed. Although this shell penetrated his ship at a vital point, it failed to explode. Good American shells brought the Jap down.

Thorough inspection of every shell with reliable gaging equipment is the only way to prevent the double tragedy of faulty ammunition. American gunners have the right to demand that every round they fire will accomplish its full share of destruction when a hit is scored.

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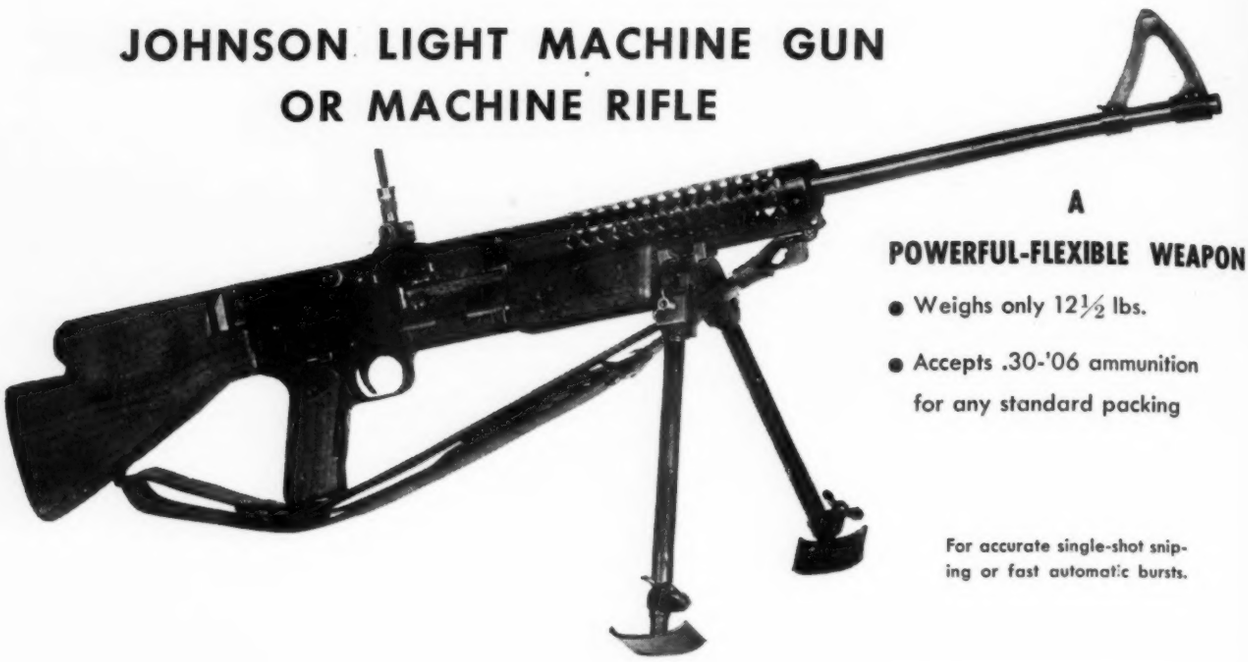

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For accurate single-shot sniping or fast automatic bursts.

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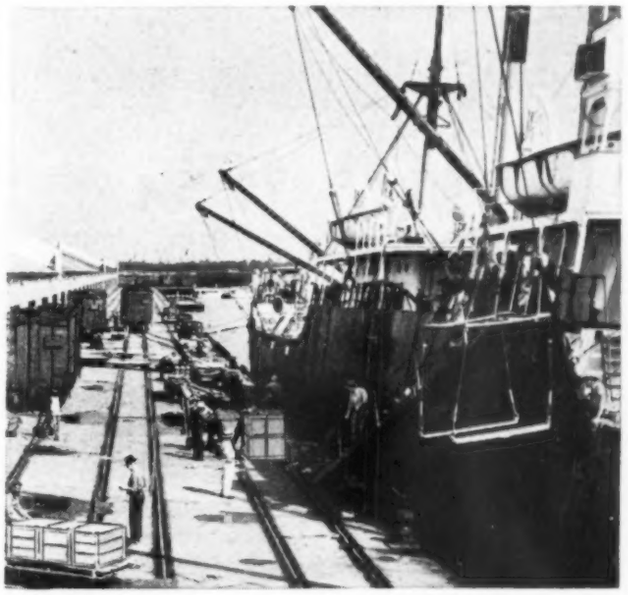

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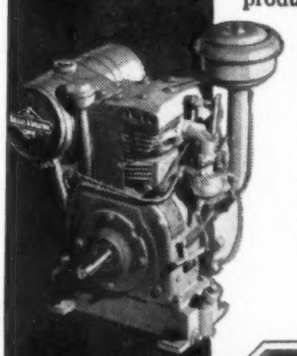

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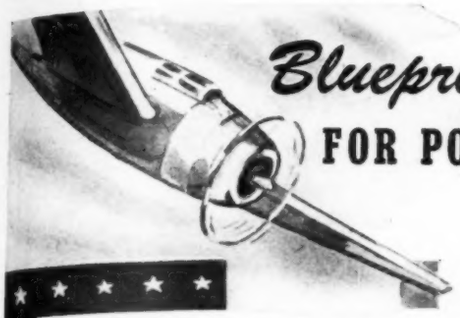

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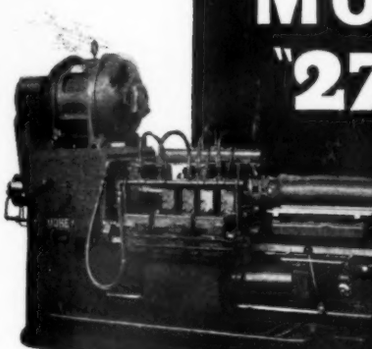

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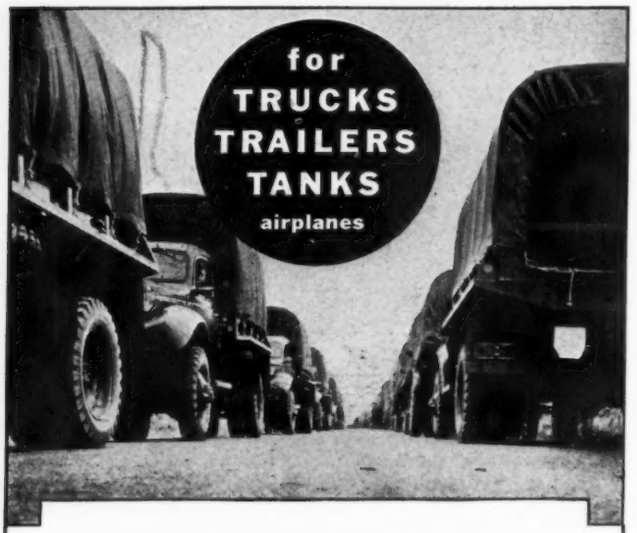

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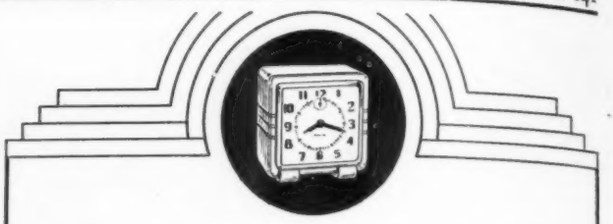

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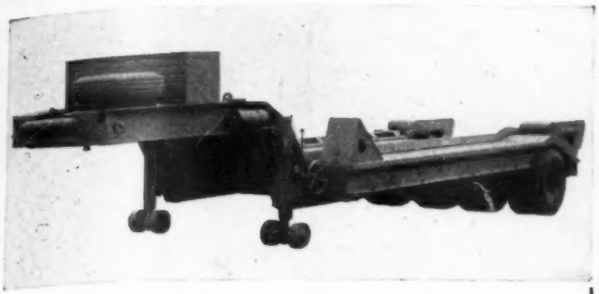

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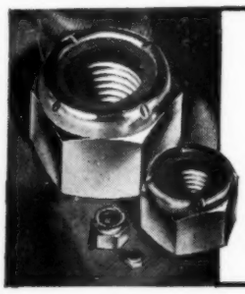

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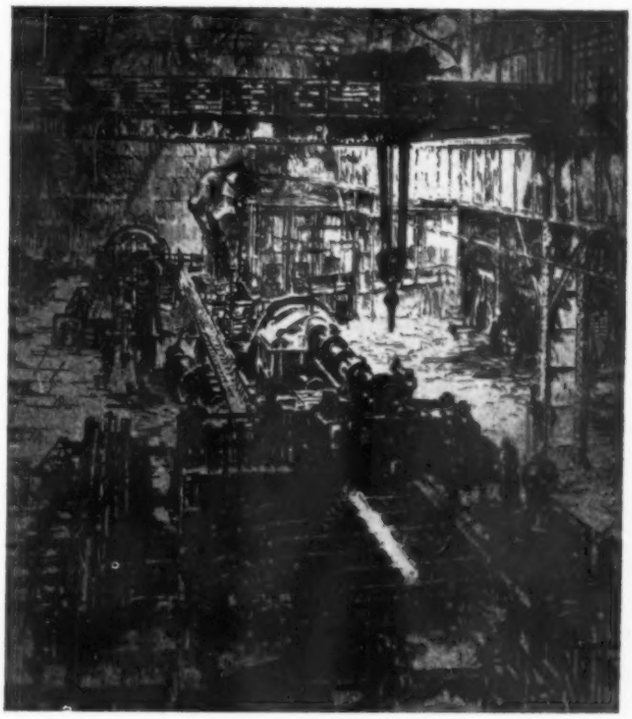

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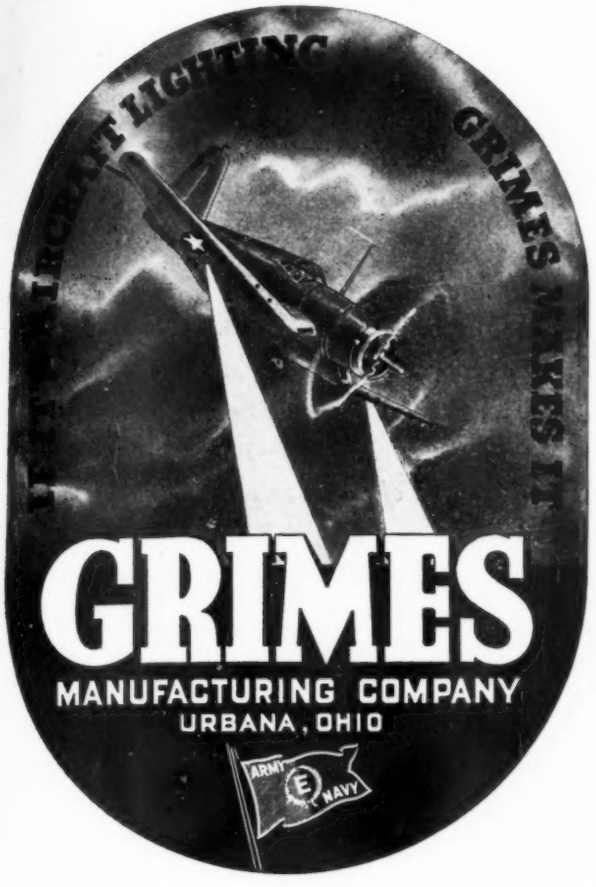

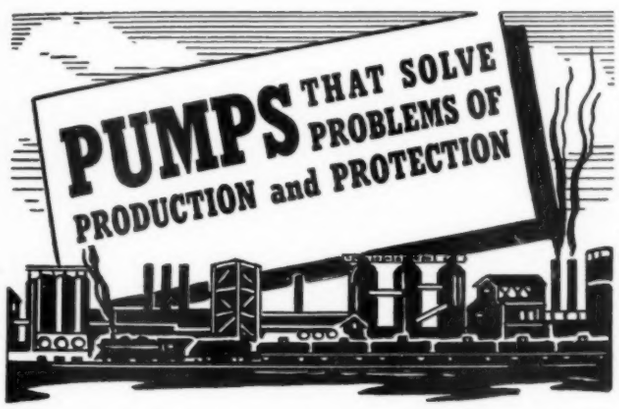

Long wear life and comparatively high efficiency have earned LaBour Pumps recognition as important production machines. LaBour engineering skill, responsible for the first practical *self-priming* centrifugal pump, has produced pumps to solve practically any liquid material-handling problem.

Protection of vital war production is another function of LaBour Pumps. Low cost, dependable fire protection is available anywhere, anytime with portable and skid or trailer mounted LaBour Fire Pumps.

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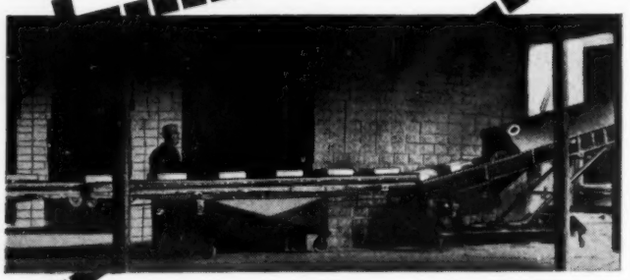

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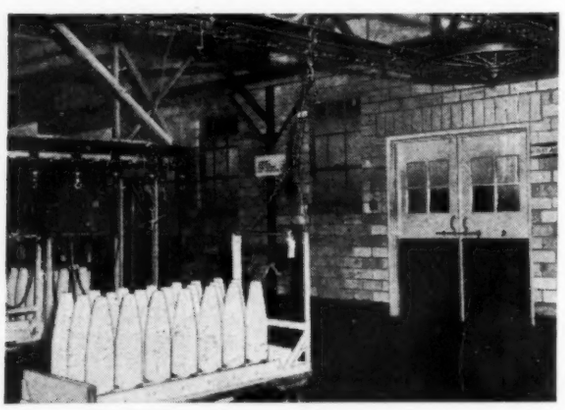
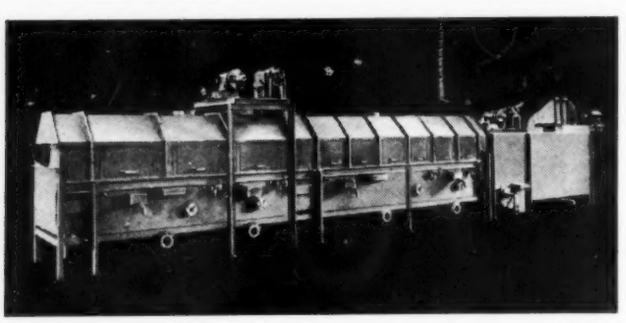


INSTALLATION of this A-F Overhead Trolley Truck-Towing Conveyor System eliminated the need for other means of towing or pushing shells and other commodities, reduced the fatigue of the men, and eliminated the danger of sparks from electric or gasoline-operated towing equipment.



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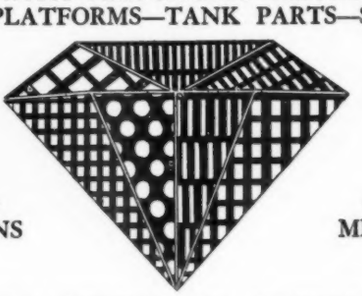

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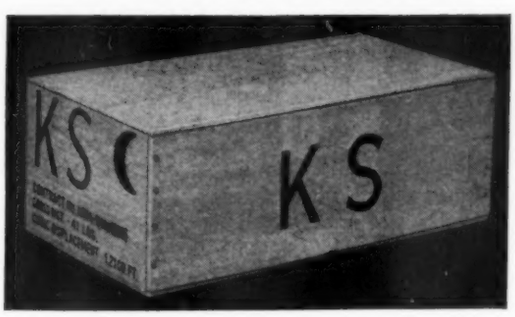

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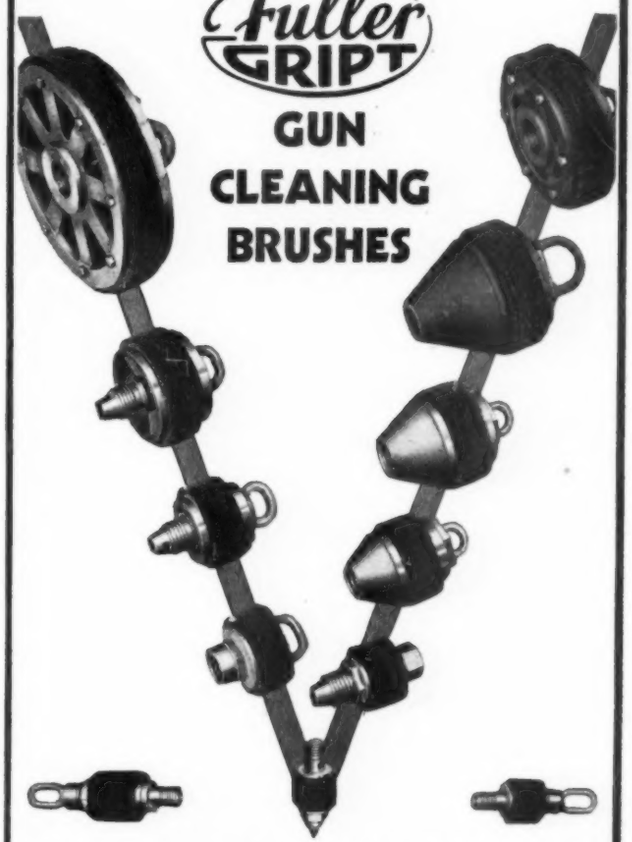

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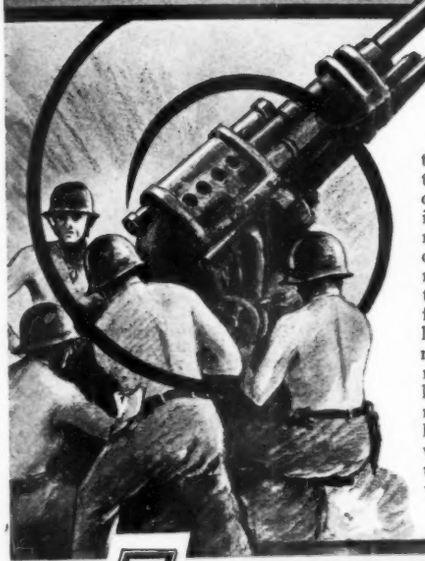

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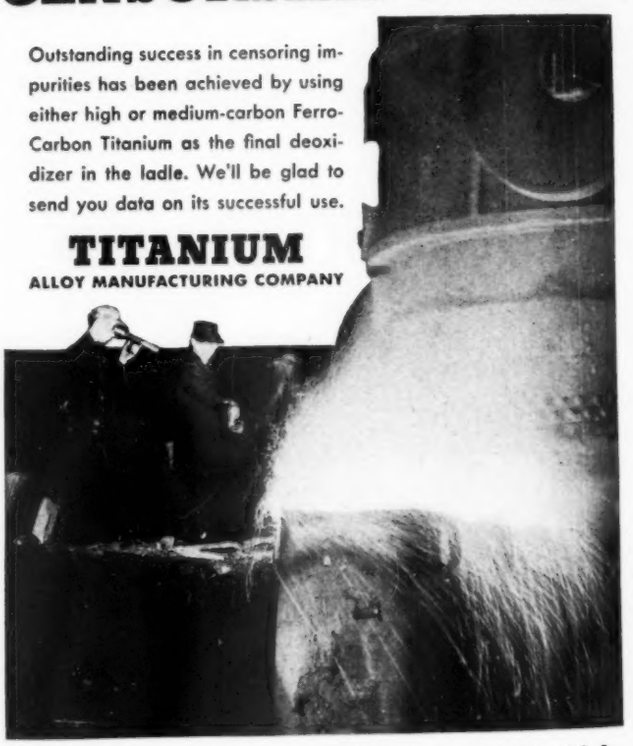

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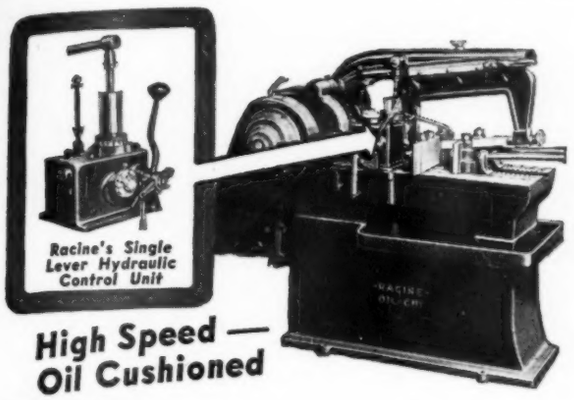

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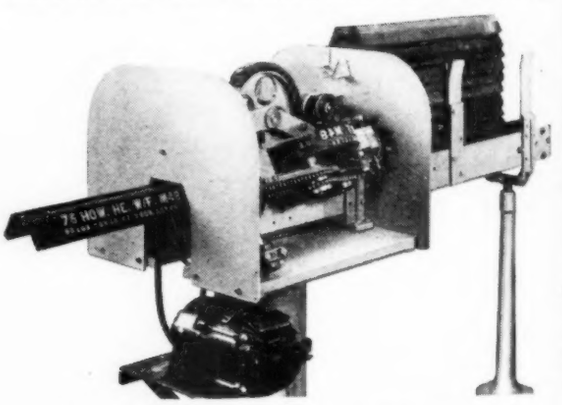

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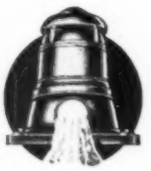

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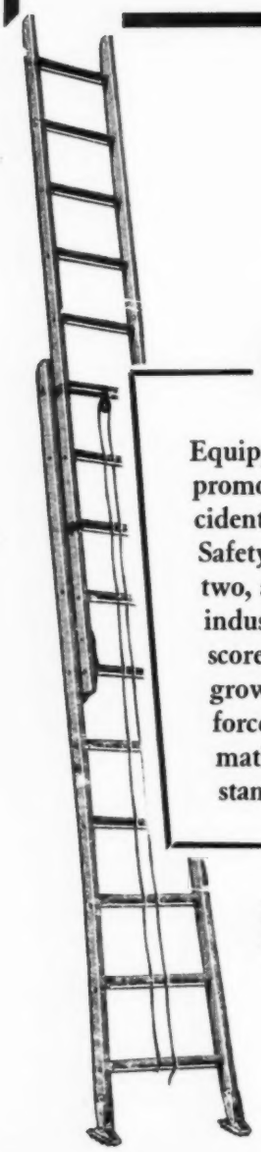

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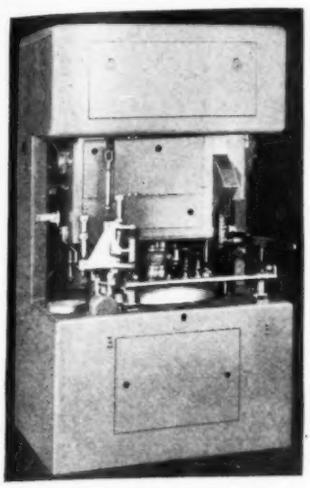

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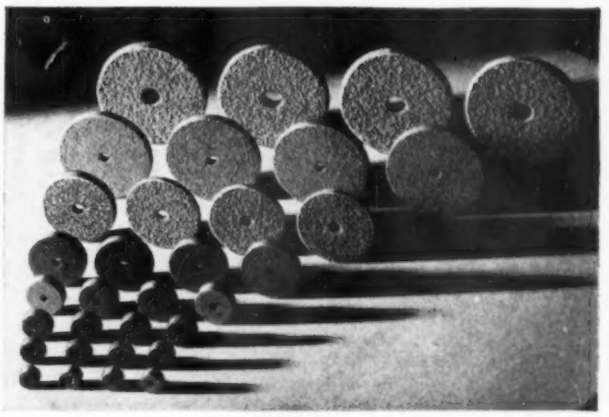

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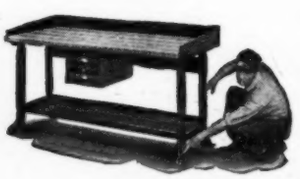

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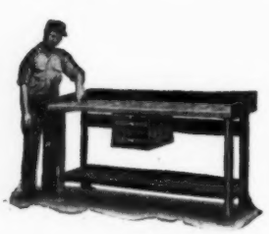

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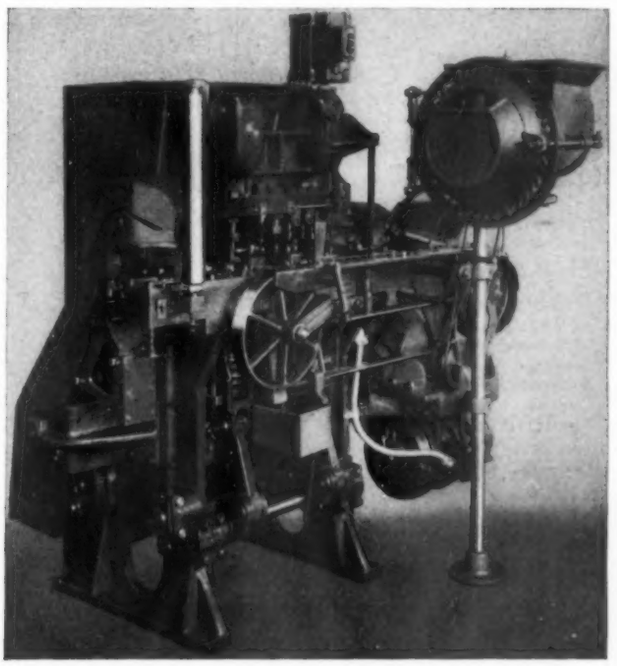

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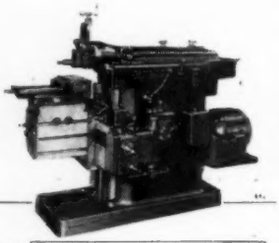

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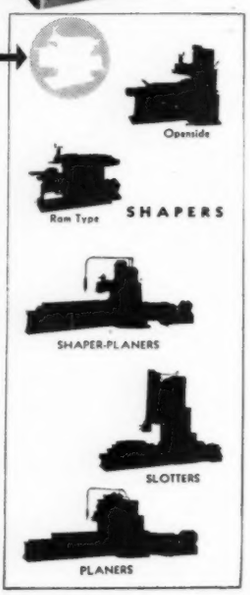

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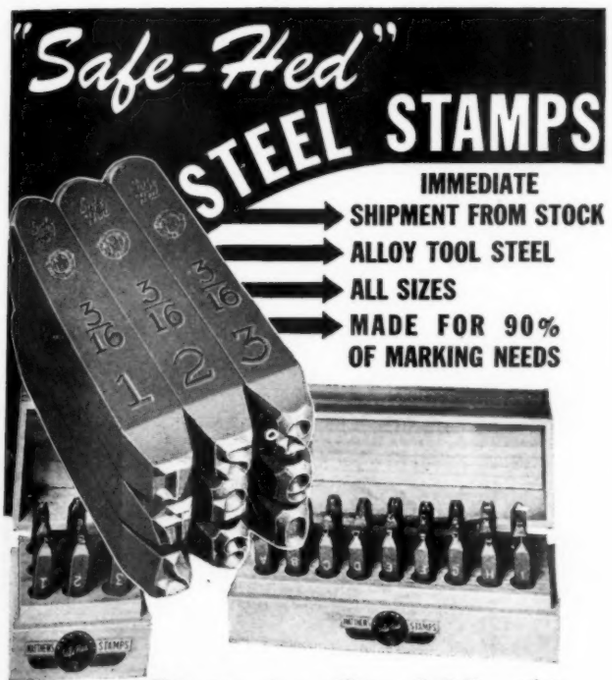

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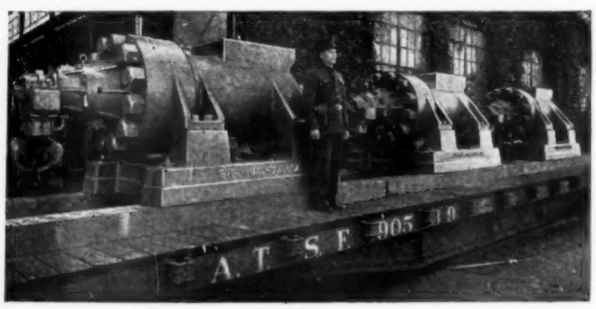

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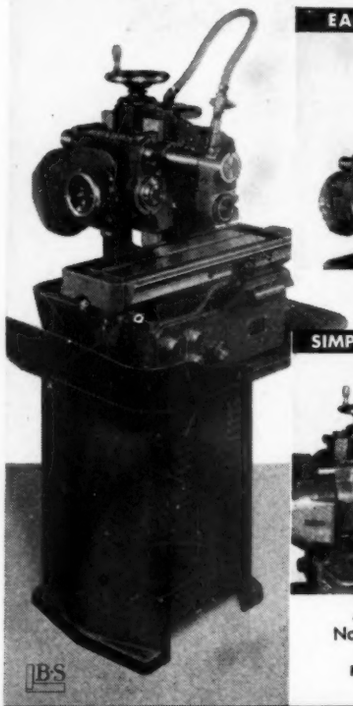

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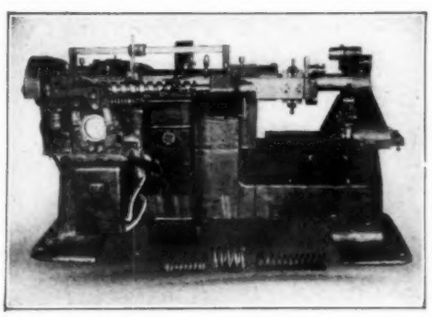

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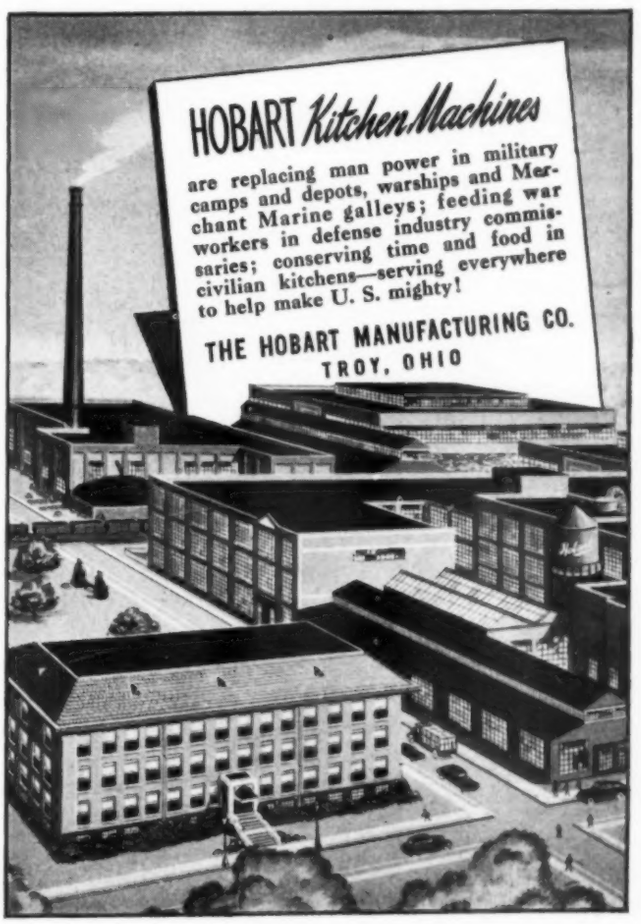
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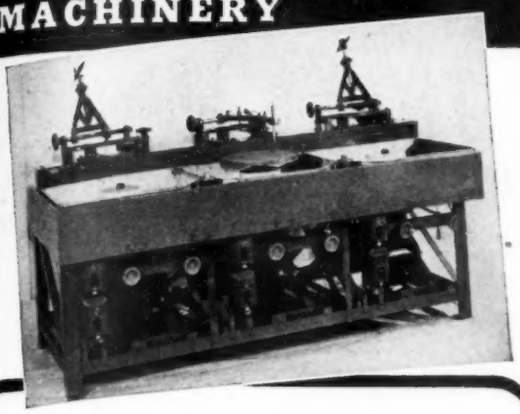

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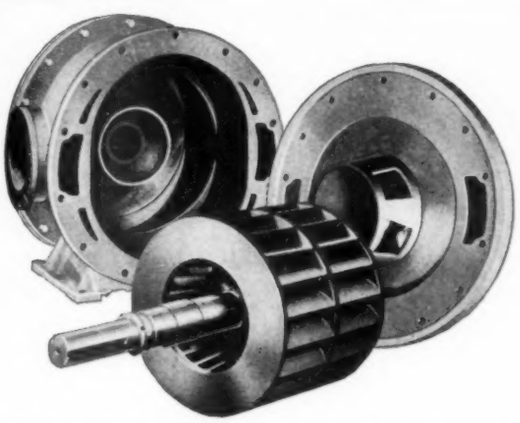

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Nash Vacuum Pumps have but one moving part, a rotor cast in one piece, and revolving without metallic contact. There are no valves, no pistons or sliding vanes, no internal parts requiring wear adjustment or lubrication.

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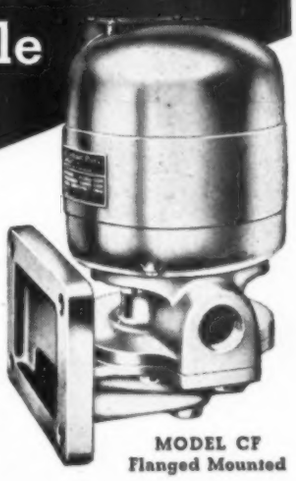

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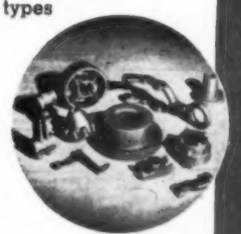

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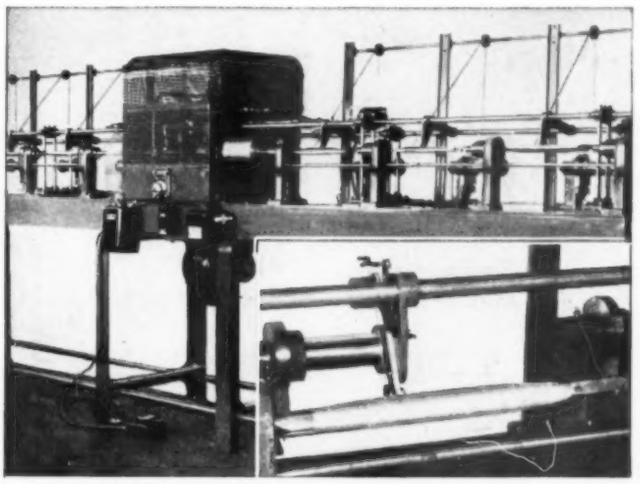

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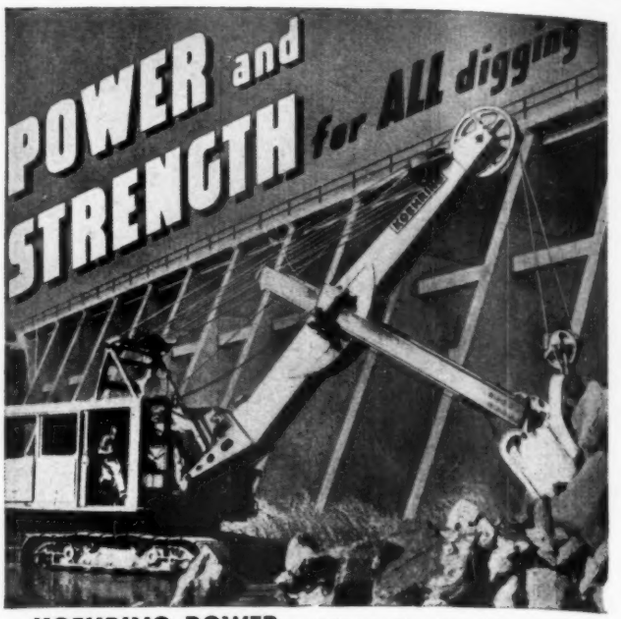

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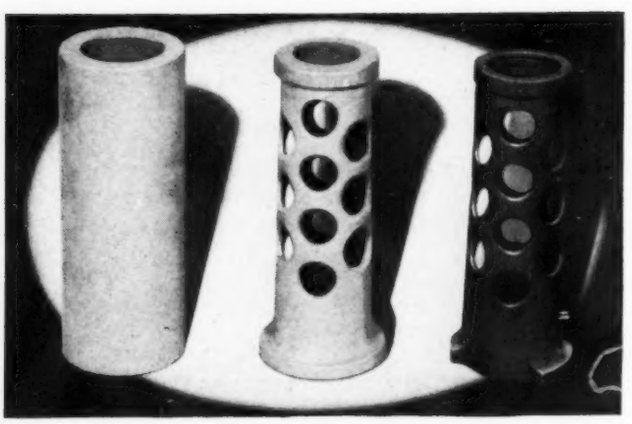

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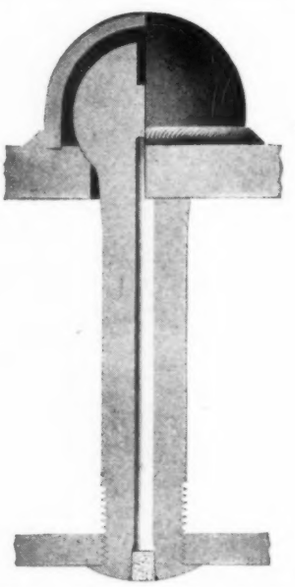

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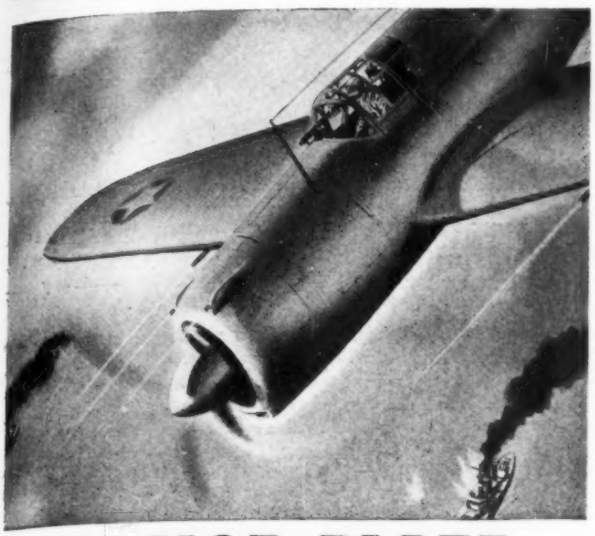

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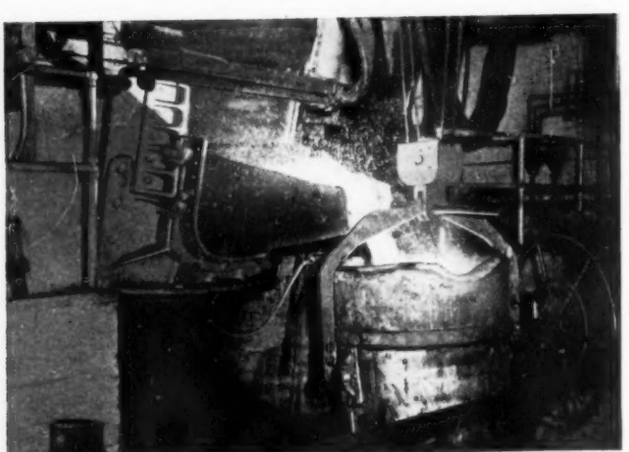

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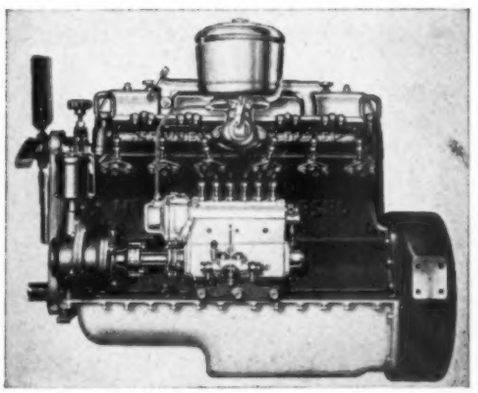

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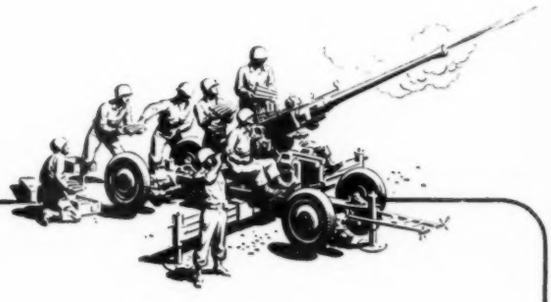

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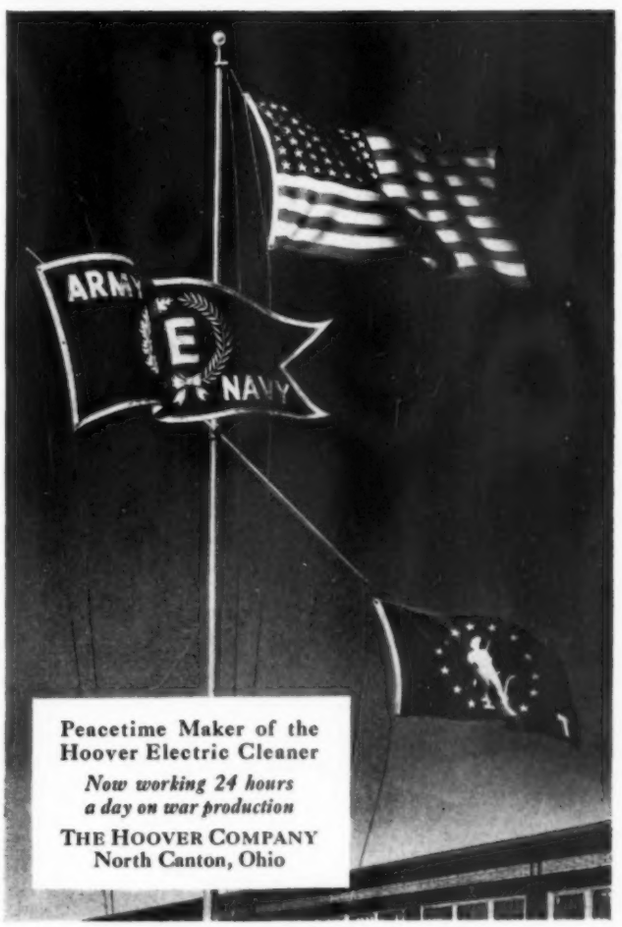

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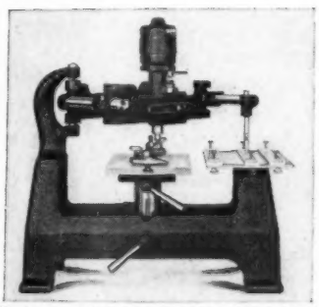

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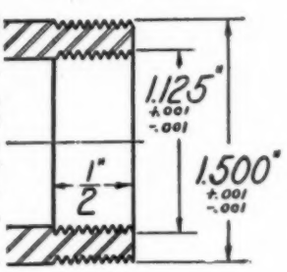

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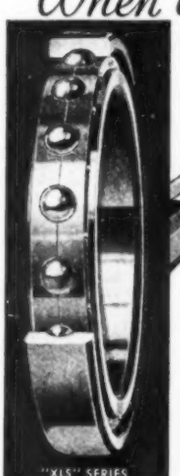

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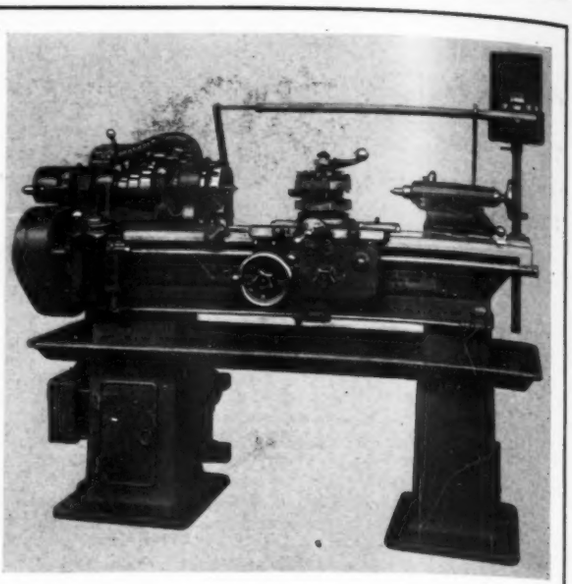

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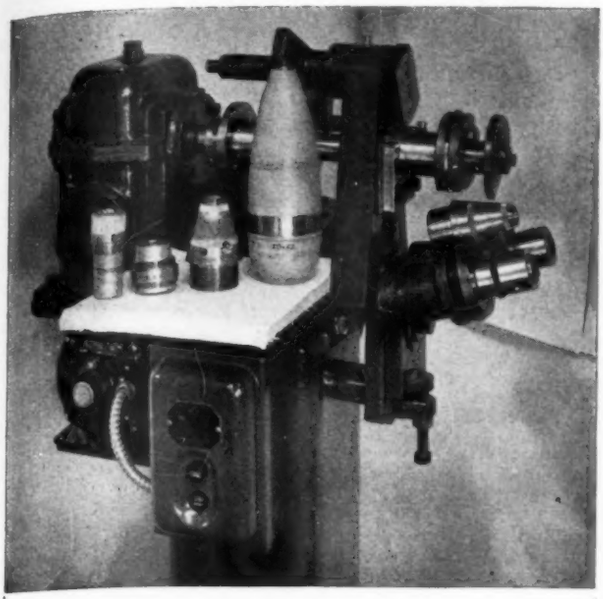

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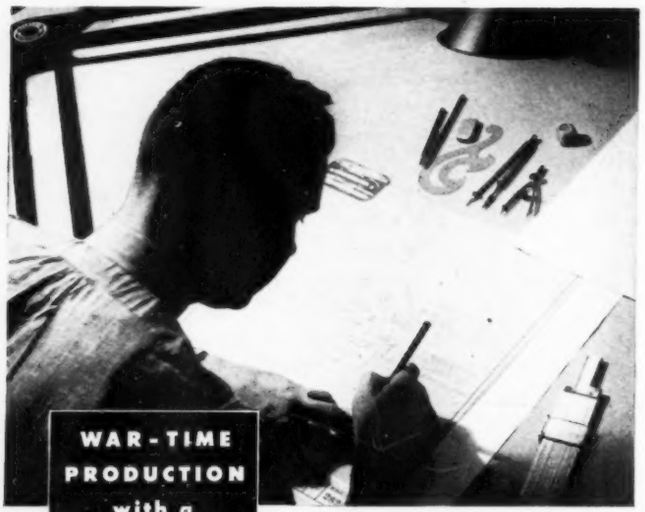

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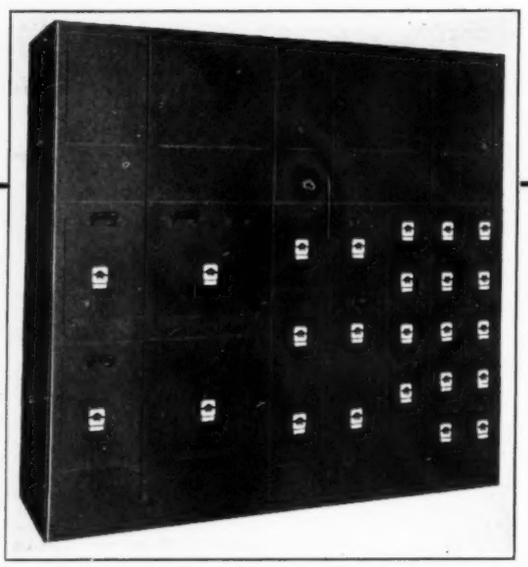

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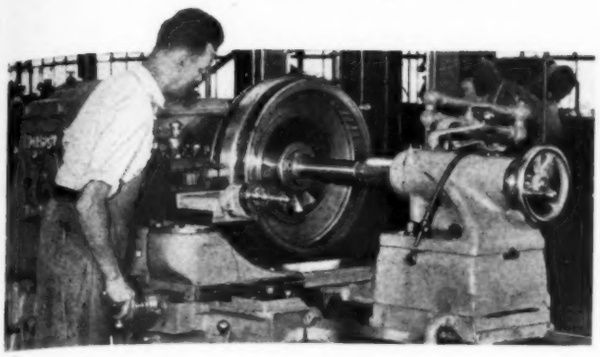
IDEA FOR THE V-SHIFT



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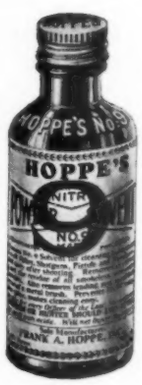

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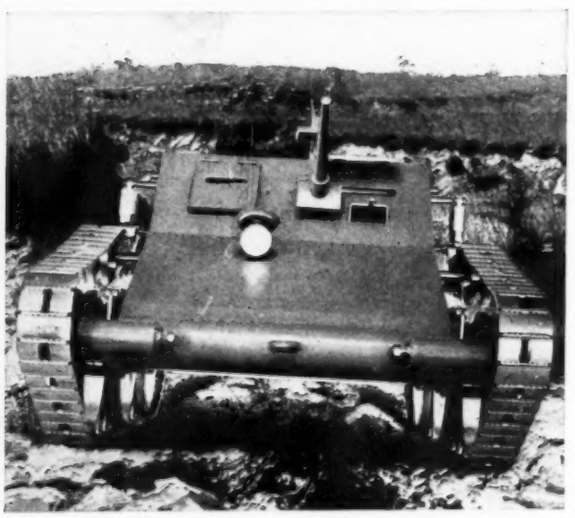

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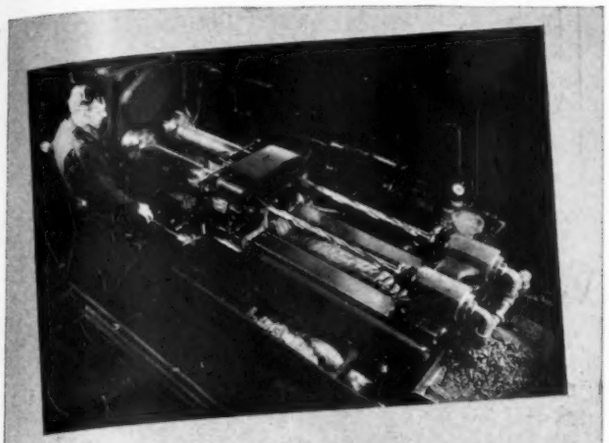

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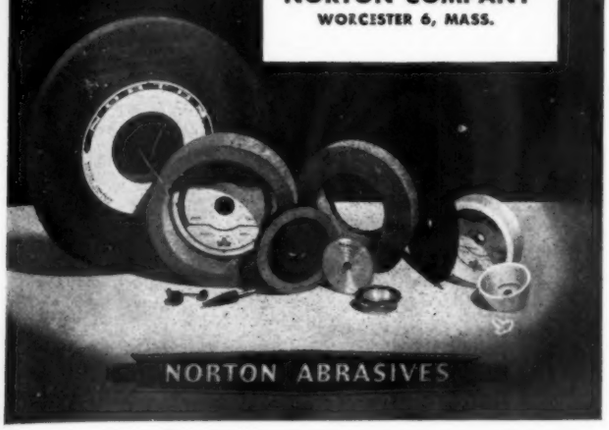

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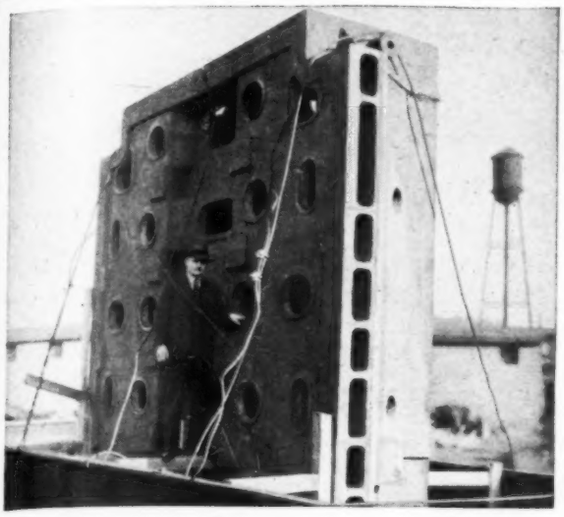

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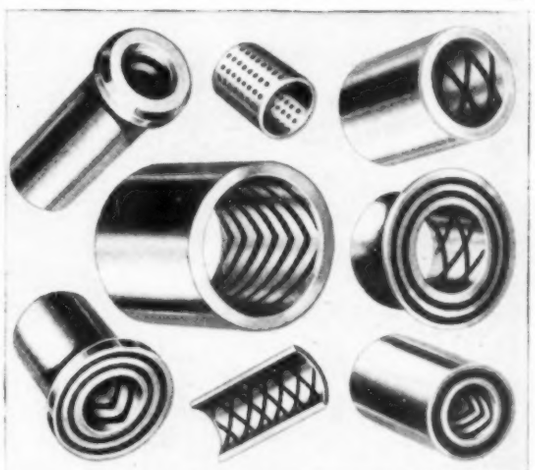

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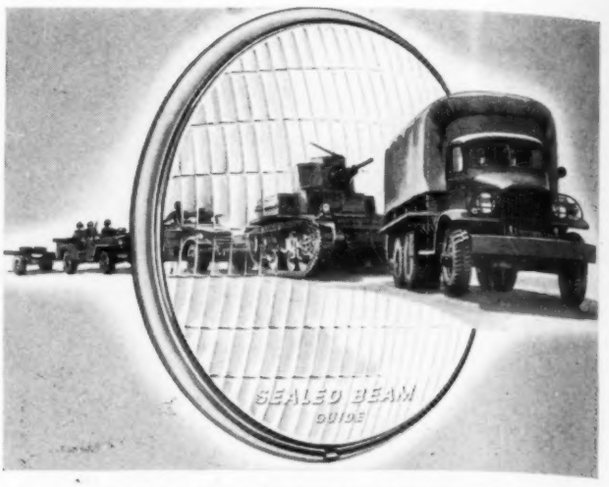

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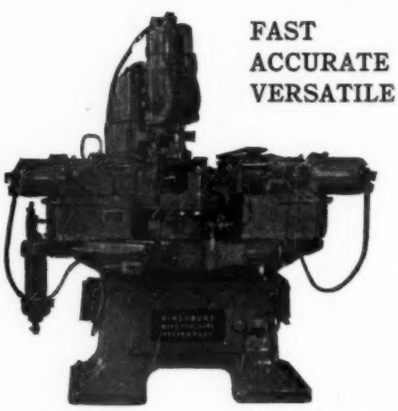

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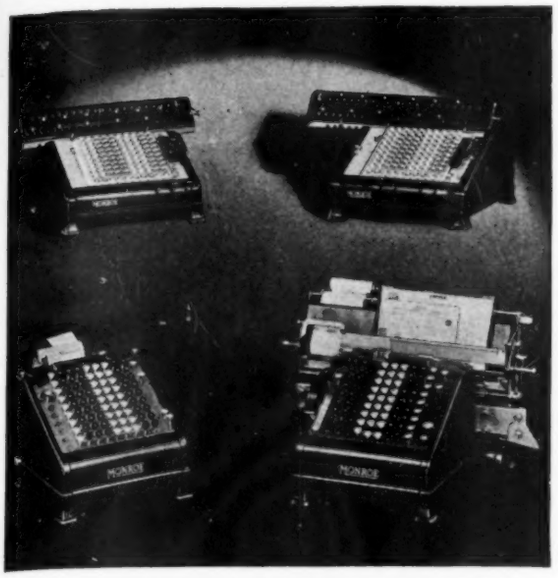

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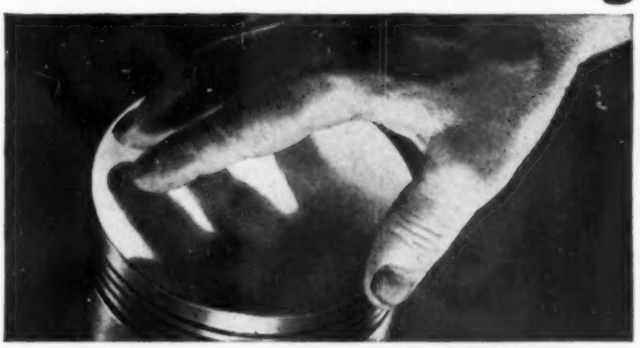

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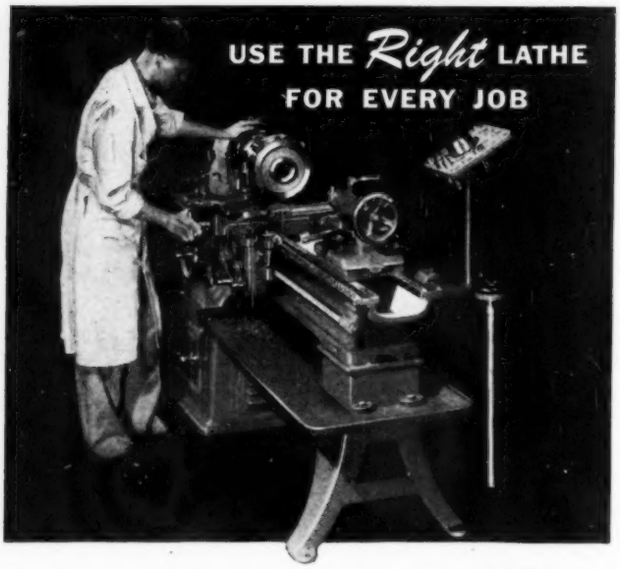

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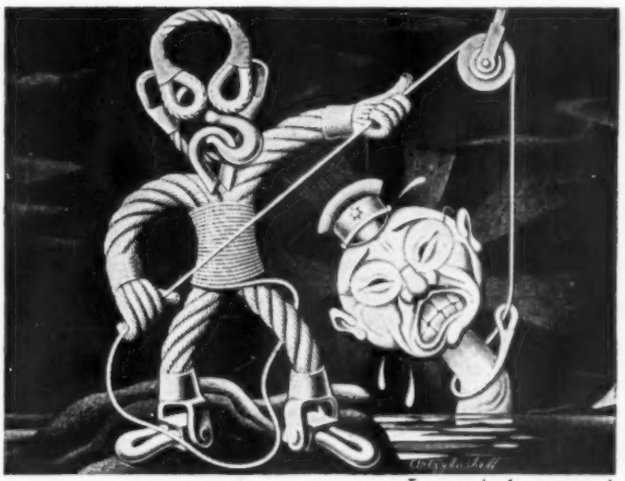

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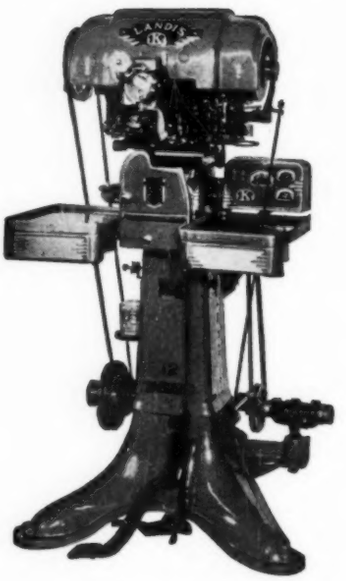

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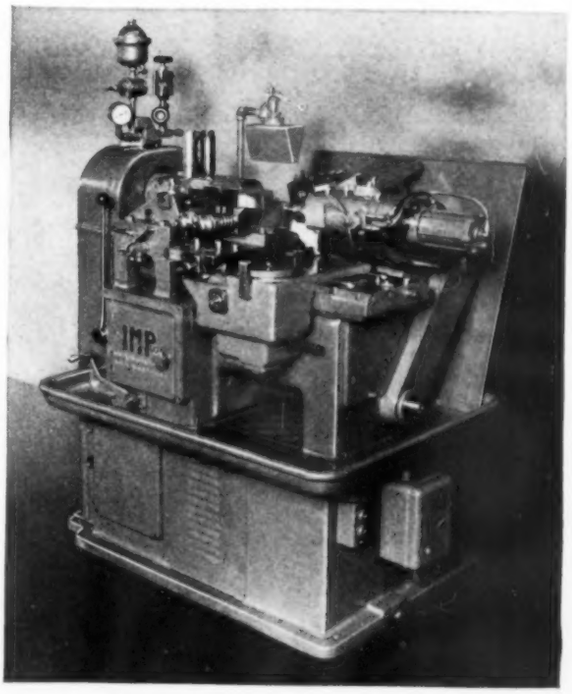

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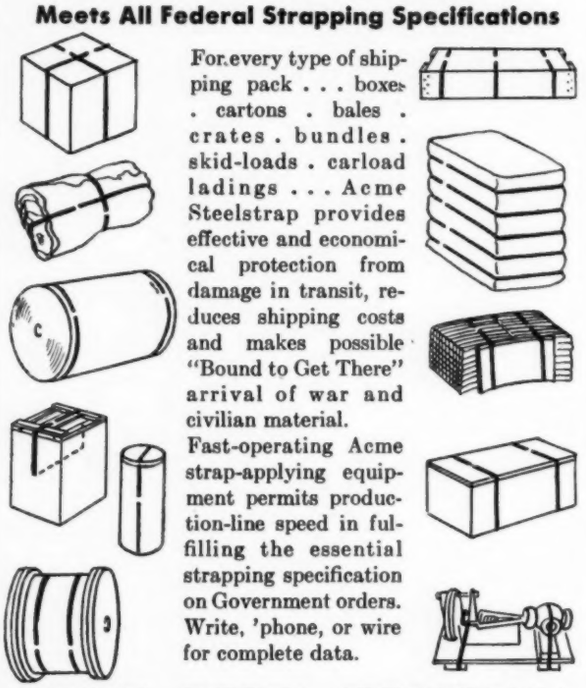

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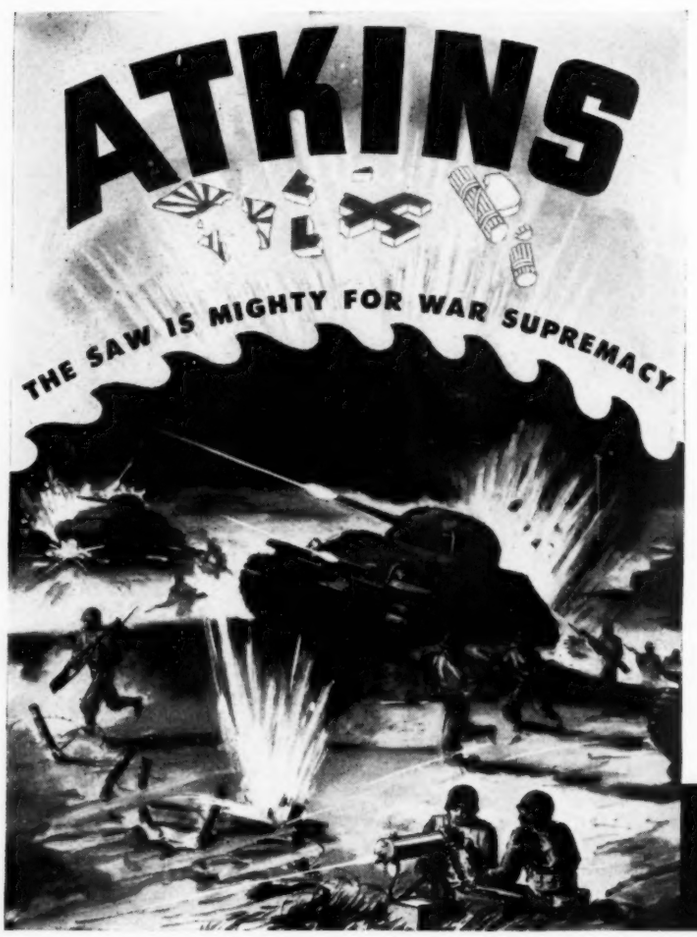

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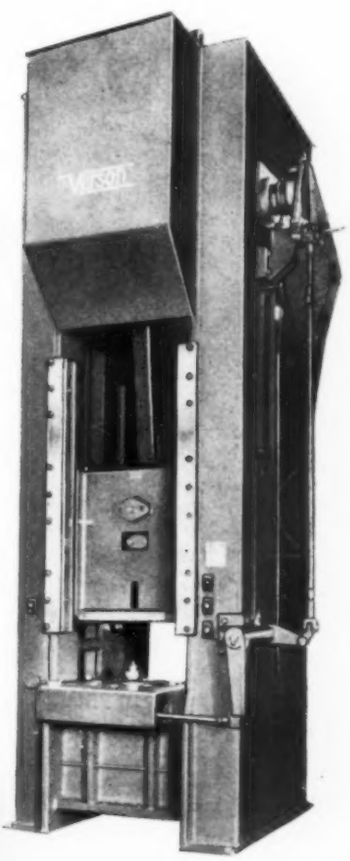


BIG BRUISERS, fast and tough, to stand up under hundreds of tons of stress, and high volume, day-in, day-out production. That describes Verson Allsteel Cartridge Case Drawing Presses, but not completely. Theirs is a precision job—a job that only a machine precisely built and skillfully machined can do right.

All of the care that goes into another big bruiser, our Flying Fortress, goes into Verson Presses. Extra long gibs securely confine the slides at all positions of the stroke — make for greater accuracy and longer die life. All gibs are bronze lined. Equipped with a dial feed, which is tied into the press circuit, the press cannot operate until dial is perfectly indexed.

As in all Verson Presses, the frame is constructed of unbreakable solid, welded steel. Verson Improved Fully Eccentric Action affords more than usual power and strength.

Ask to see a Verson Engineer. Perhaps he can help you with your forming, drawing or punching problems. There will be no cost or obligation, of course.

VERSON—ORIGINATORS OF ALLSTEEL PRESSES

VERSON ALLSTEEL PRESS COMPANY

9308 South Kenwood Avenue • Chicago, Illinois

POWER PRESSES • HYDRAULIC PRESSES • CLUTCHES
FORGING PRESSES • PRESS BRAKES • DIE CUSHIONS

LEGIBLE STENCIL MARKINGS *delivers* the goods

Crates, boxes, barrels, packages . . . any kind of shipment gets delivered quickly when the address is stenciled. Stencils cut on Marsh Stencil Machines assure clear, bold, permanent markings that expedite handling of your shipments. Marsh machines are available for prompt delivery on priority. Write for free booklet.

MARSH

MARSH STENCIL MACHINE CO.
22 MARSH BUILDING
BELLEVILLE, ILL., U. S. A.

McQUAY NORRIS

TIME TESTED · McQUAY-NORRIS · AUTO PARTS · PROVEN IN SERVICE

Manufacturers for 33 years of precision parts for motors used in passenger cars, trucks, tractors, and industrial installations.

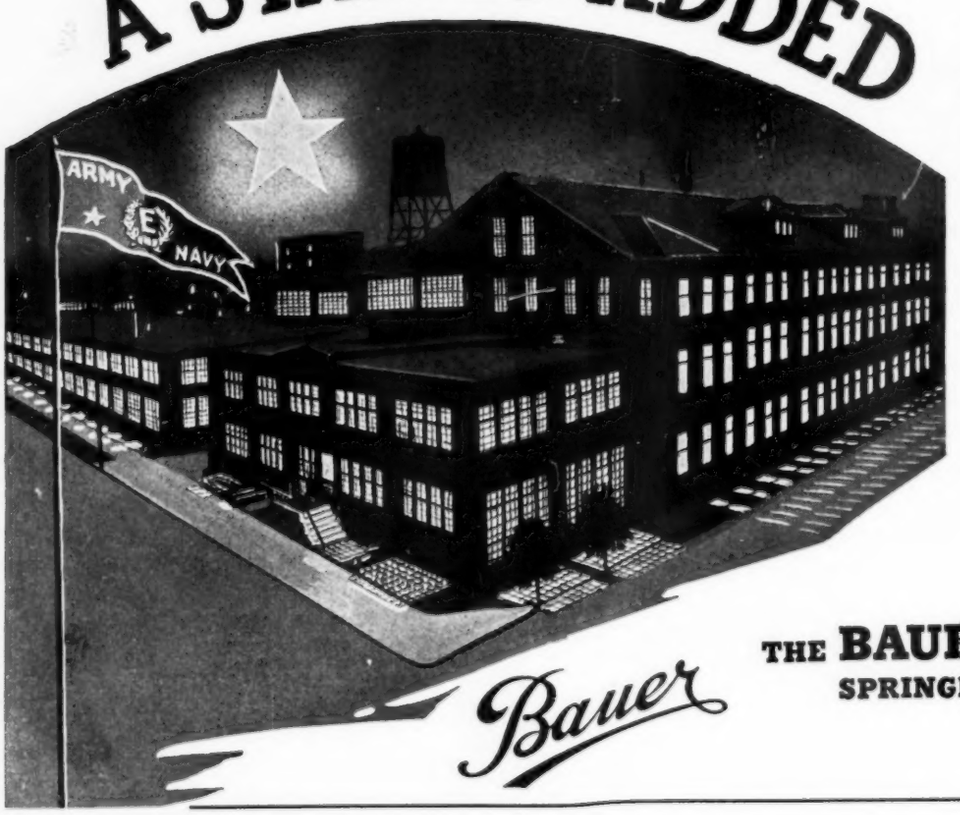
Now direct contractors to the Army and Navy and subcontractors on parts for aircraft, tanks, scout cars, and trucks.

ARMY E NAVY

Awarded to two plants—
McQuay-Norris Ordnance Management Division.

McQUAY-NORRIS MFG. CO.
St. Louis, Mo.

A STAR IS ADDED



There's one particular star that interests us deeply . . . the star that goes on an Army-Navy E pennant for additional meritorious service. We were awarded the pennant in 1942. We have now won that star.

With our entire plant dedicated to long, hard hours of intensive war production, victory has become our business.

Bauer

THE **BAUER BROS.** CO.
SPRINGFIELD, OHIO

Do away with FIRE HAZARDS

USE JUSTRITE *Safety* FILLING CANS

● For use in handling and pouring gasoline or other 'flammable liquids with minimum fire risk. Made of lead-coated 24-gauge steel double seamed and soldered. Flexible nozzle to eliminate splashing. Air vent in pouring spout assures even flow. Approved and listed by Underwriters' Laboratories, Inc., and Associated Factory Mutual Fire Insurance Cos. Size — 20 quarts.

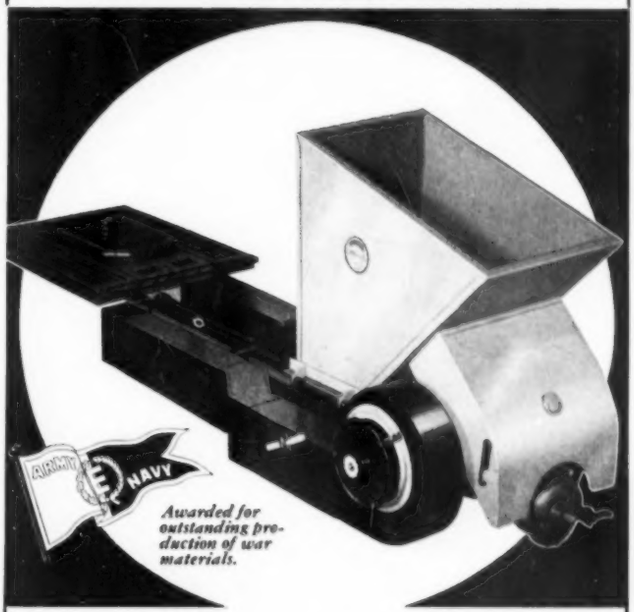
Justrite Safety Cans, similar to above but without spout, protect plant and reduce fire insurance. *Justrite Twin-Bulb Electric Lanterns* give safe light in hazardous locations.

For details and prices, see your jobber or write direct.

JUSTRITE MANUFACTURING CO.
2075 N. Southport Avenue, Chicago, Illinois

JUSTRITE *Safety Products*
SAFETY CANS · FILLING CANS · OILY WASTE CANS
APPROVED SAFETY ELECTRIC LANTERNS

USED BY ARMY CAMPS THE COUNTRY OVER!



Awarded for outstanding production of war materials.

WINKLER
fully automatic **STOKERS**
U. S. MACHINE CORPORATION • LEBANON, INDIANA

LINN HAFTRAKS HAVE THE POWER TO PLOW THE DRIFTS

Stamina, drive and structural strength are built into LINN HAFTRAKS for the hard work of clearing heavy snowdrifts in open country.

The exclusive CONTOUR-FOLLOWING TRACTION makes Linn Haftraks as effective for winter service as for off-the-road operations throughout the other seasons.

THE LINN MANUFACTURING CORPORATION, Morris, N. Y.

AXELSON *insists on* QUALITY

Excerpt from a recent issue of Axelson CONTACT, published by Axelson Manufacturing Company, pioneer producer of oil well pumping equipment, engine lathes, gages, and aircraft parts, of Los Angeles, California.

Send for free copy of the new Pentrate book

HEATBATH CORPORATION
Springfield, Massachusetts

"PENTRATE"

A CHEMICAL PROCESS WHICH HELPS IN THE MAINTENANCE OF AXELSON QUALITY

Quality has been an Axelson tradition for fifty years. During that time many new ideas have been developed and put into use in order to assure and maintain quality throughout every Axelson manufacturing step.

One of the many departments installed to make possible the production of better equipment for better service is the "Pentrate" department. This division is devoted entirely to the process involved in giving various metal parts a non-plated, rust resistant black satin-like finish that will stand up against many forms of corrosion.

The Pentrate department is in the capable hands of Joe Palma, whose wide background includes a close association with industrial chemistry for many years.

The Pentrate method of product finishing is a development of the Heatbath Corporation of Springfield, Mass., and constitutes a concentrated processing bath which applies, through chemical action, a penetrating, durable satin-black surface to products made of steel.

Pentrate is not a plating process, and does not, in itself, create corrosion resistance. Rather, it is a process by which certain chemical salts are caused to penetrate the outer surface of the metal. The rust and corrosion resistant factors are brought about by the fact that oil or other lubricants will adhere far more readily to a Pentrated surface than to a non-processed surface. Once a part has been through the Pentrate process it can be oiled and, when wiped dry (not chemically washed), can be successfully subjected to many of the standard tests for rust and corrosion resistance.

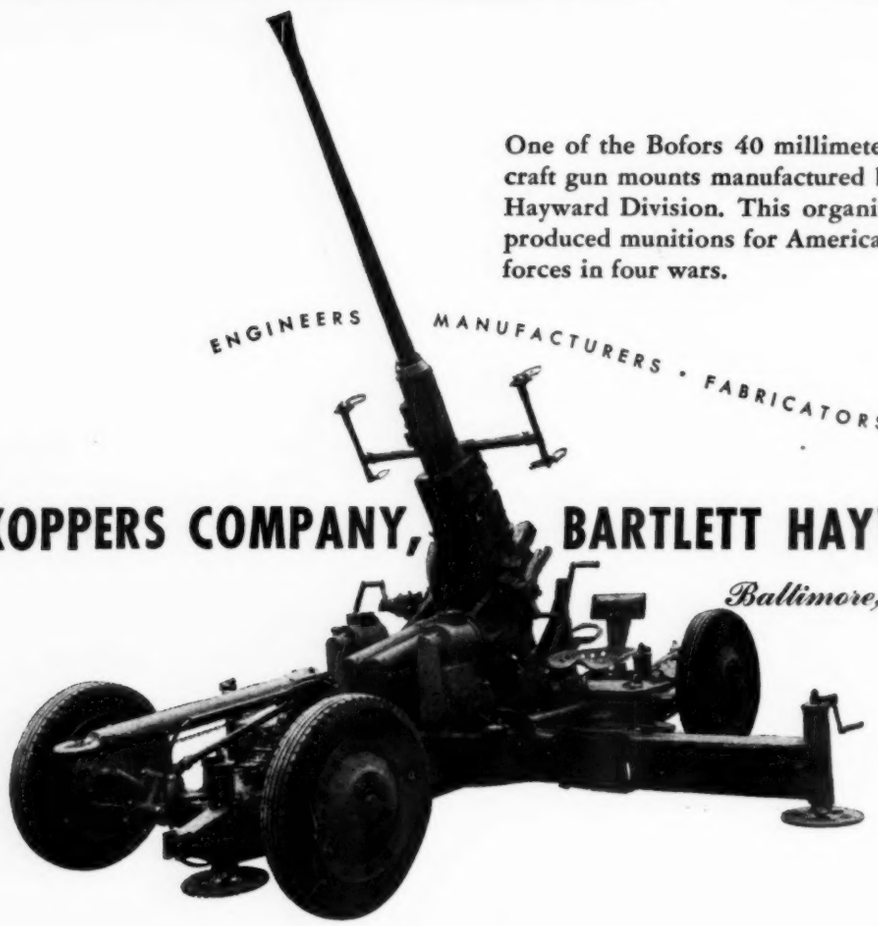
Pentrate is not a superficial "cover-up" coating — it is an actual penetration. Consequently the appearance of a Pentrated surface depends upon the finish of the metal before processing. Spots, flaws, grinding checks, etc., will still show if present on the surface to be processed.

Laboratory tests and the results shown by parts in daily service prove that because of the friction-reducing feature of being more capable of retaining a lubricant, Pentrated surfaces will last longer and give more satisfactory service.

Cutting-tool efficiency has also been greatly increased when the tool is Pentrate-processed because the sleek finish thus provided goes a long toward stepping up the discharge of chips, thereby helping to eliminate "loading" the tool.

Many products formerly finished by such methods as lacquering oxidizing, or saltpeter bluing can be more satisfactorily handled by the Pentrate process. Pentrate, too, looks better, will not chip, peel, crack, or rub off, and in most cases is very inexpensive in its application.

Master Chemist Joe Palma personally watches every phase of Pentrate processing. Note attention to process formulas in Joe's record of success in this department.



One of the Bofors 40 millimeter anti-aircraft gun mounts manufactured by Bartlett Hayward Division. This organization has produced munitions for American fighting forces in four wars.

ENGINEERS MANUFACTURERS • FABRICATORS • ERECTORS

KOPPERS COMPANY, BARTLETT HAYWARD DIVISION

Baltimore, Maryland

DIESEL ENGINES

MACHINE TOOLS

THE NILES TOOL WORKS CO.

THE HOOVEN, OWENS, RENTSCHLER CO.

DIVISIONS

GENERAL MACHINERY CORPORATION

HAMILTON, OHIO

Every Ausco Worker
IS ON THE
War Production Front
All of Ausco's workers feel a glow of pride that they too are on the firing line for Freedom. Following is a partial list of War Materials Ausco is helping to produce:
Ordnance Ammunition Steel Castings
Armor Piercing Shells
Trench Mortar Bombs
Complete Tracks for Tanks and Combat Vehicles
Hydraulic and Mechanical Jacks for Quartermaster's Corps
AUSCO
• Mechanical & Hydraulic Jacks • Body Repair Tools • Lambert Disc Type Tractor Brakes • Malleable Iron & Steel Castings, Rough and Machined
ARMY NAVY
AUTO SPECIALTIES MFG. CO.
GENERAL OFFICE, ST. JOSEPH, MICHIGAN
PHONE 3-2521 CABLE ADDRESS: AUSPECO

TWO MINUTES from Mule Back to "Ready . . . Fire!"

To unload from mule-back, completely assemble, and have the 75-mm. pack howitzer firing in only two minutes, requires well-trained, well-coordinated gun crews. It also requires precise machining of all the gun parts, and a high degree of accuracy in their manufacture to insure quick and easy assembly and absolute interchangeability of parts.

For these highly efficient little howitzers, which combine superior striking power with unequalled portability, The J. G. Brill Company has been privileged to build a large number of gun carriages. In addition, we are supplying trailers for anti-aircraft generators, hydraulic press forgings of many kinds, sheet metal work, machining, woodwork and seating.

THE J. G. BRILL COMPANY
PHILADELPHIA PENNSYLVANIA
"Brill-built is well built"

THE MASTER JACKLIFT

STILL the Only Mechanical Lift Truck with ALL the Good Features

"Easier Handling"

CATALOG 21

LEWIS-SHEPARD PRODUCTS INC.

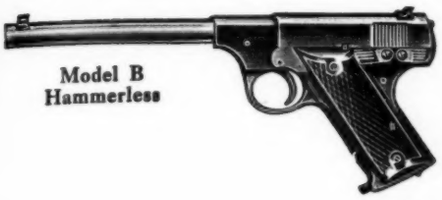
705 WALNUT STREET, WATERTOWN, MASS.

Engineering Service in all Principal Cities .. Factory Branch, Crawfordsville, Indiana

LEWIS-SHEPARD

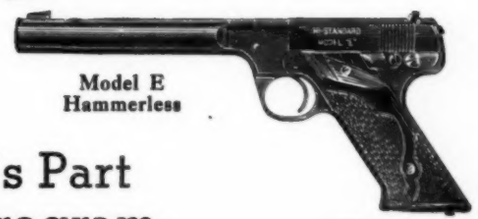
Multiply Man Power

HIGH STANDARD
.22 Automatic Target Pistols



Model B
Hammerless

BUILT TO EXTREME PRECISION STANDARDS BY GUN EXPERTS



Model E
Hammerless

Model HE
Visible Hammer

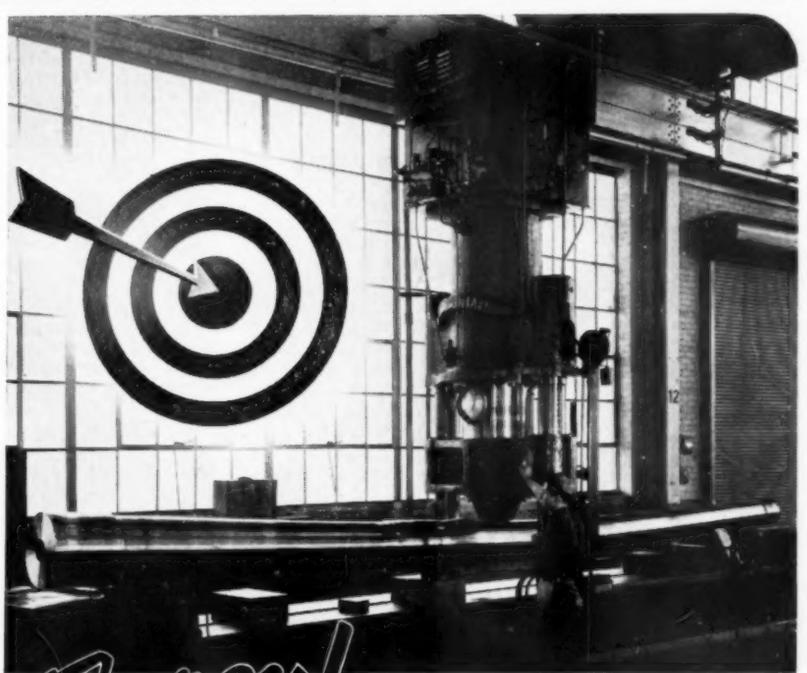
Hi-Standard's Part In The War Program

is the manufacture of machine guns for the army and navy, and deep-hole drills for other manufacturers supplying machine guns, rifles, tanks, trucks, and airplanes. On both these items, we are now in full production.

THE HIGH STANDARD MFG. CORP., NEW HAVEN, CONN.

Straight Shooting with Farquhar

The recognized firepower of American-made guns with their "straight-shooting" quality, is leading our boys onward—to Berlin—to Tokyo and to Victory. To produce these "straight-shooting" guns many war production plants are using Farquhar hydraulic presses to straighten gun barrels which have an excess runout. This picture was taken with the gun barrel on the press under 750,000 lbs. pressure. Farquhar presses are built in all sizes and capacities from 3 to 7,200 tons.



Farquhar

- HYDRAULIC PRESSES
- MATERIAL HANDLING CONVEYORS
- SPECIAL MACHINERY

A. B. FARQUHAR CO., Limited . . . York, Pennsylvania

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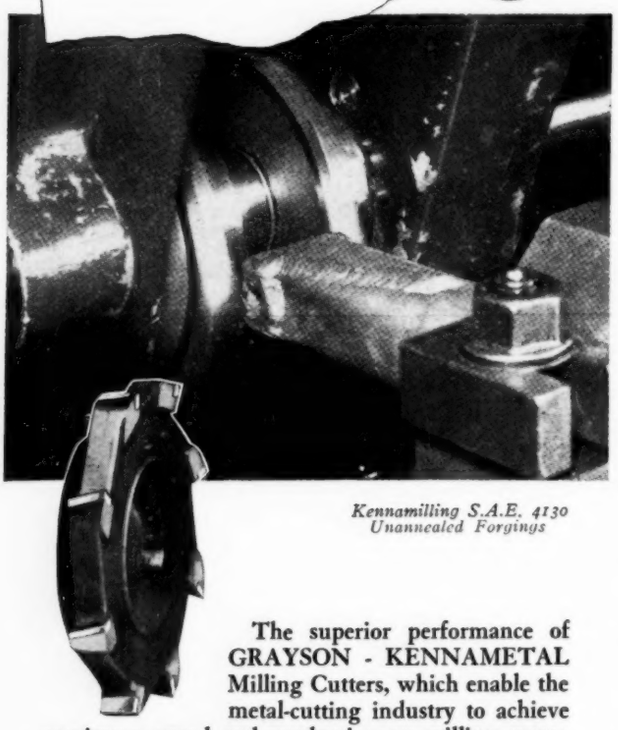
"MORE *Milling* WITH FEWER MACHINES"



Kennamilling S.A.E. 4130 Unannealed Forgings

The superior performance of GRAYSON - KENNAMETAL Milling Cutters, which enable the metal-cutting industry to achieve maximum speed and production on milling operations, is clearly demonstrated by the many reports received from satisfied users.

For example, when a pair of 6″ diameter GRAYSON-KENNAMETAL half side mills, with 10° negative helix were used to "Kennamill" S.A.E. 4130 Forgings (no heat treatment) with a chip load of .0047 per tooth and a feed of 15¼″ per minute, the user wrote:

"These cutters were used to Straddle Mill boss ⅞″ in diameter, removing 1/16″ from each side. The cutters were mounted on a No. 2 L. H. Milwaukee, and *produced 80 pieces per hour for seven hours . . . 560 pieces between grinds.* This is really a production record, because *we were able to turn out four times as many pieces per hour as we could before.* It seems to prove your slogan 'More Milling with Fewer Machines' ".

KENNAMETAL THE All American CARBIDE

Write for complete information. Let us help you solve your metal-cutting milling problem.

KENNAMETAL Inc.

331 Lloyd Ave., Latrobe, Pa.

Trade Mark Reg. U. S. Pat. Off.

Foreign Sales: U. S. STEEL EXPORT CO., 30 Church St., New York (Exclusive of Canada and Great Britain)

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[Army Ordnance—*composition, presswork and binding—is the work of The William Byrd Press, Inc., Richmond, Va.*]

5 PLANTS PRODUCING Ordnance Equipment for UNCLE SAM . . . .

We are utilizing the equipment and personnel of all our five plants to help Uncle Sam speed up the ultimate Victory.

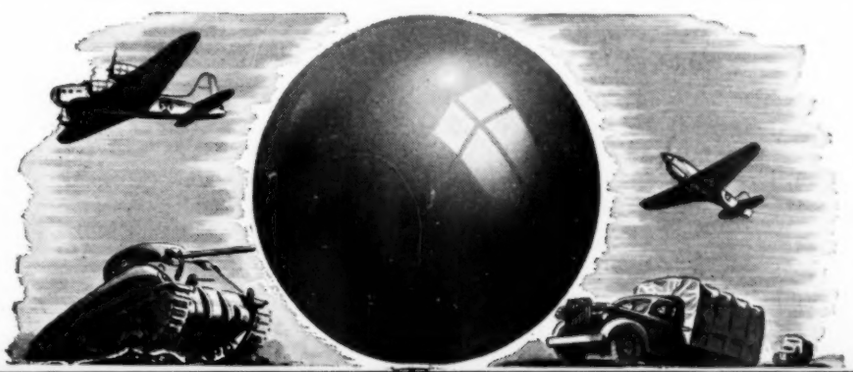
Day and night we are maintaining production of vital ordnance equipment to help the United Nations' Armies, Navies, and Air Forces to bring the present war to a speedy close and an eventual and permanent peace.

We Must Win — We've Got To Win — WE WILL WIN

FEDERAL LABORATORIES, INC.

Specialists in Scientific Law Enforcement and Ordnance Equipment

185 FORTY-FIRST STREET CABLE ADDRESS FEDERALLAB PITTSBURGH, PA.



More Bearing Mileage With STROM STEEL BALLS

In America's vast war production program Strom steps up its untiring energies to the mastery of one thing. For over a quarter century Strom has concentrated on Metal Balls. Today, through a series of lapping operations, Strom Balls possess a degree of surface smoothness and sphericity that is unequalled in any other regular grade of ball. . . . Correct hardness, physical soundness and size accuracy in all Strom Balls is assurance of More Bearing Mileage. For longer trouble-free bearing life specify Strom Metal Balls in ALL ball bearings.

Largest independent and exclusive Metal Ball Manufacturer

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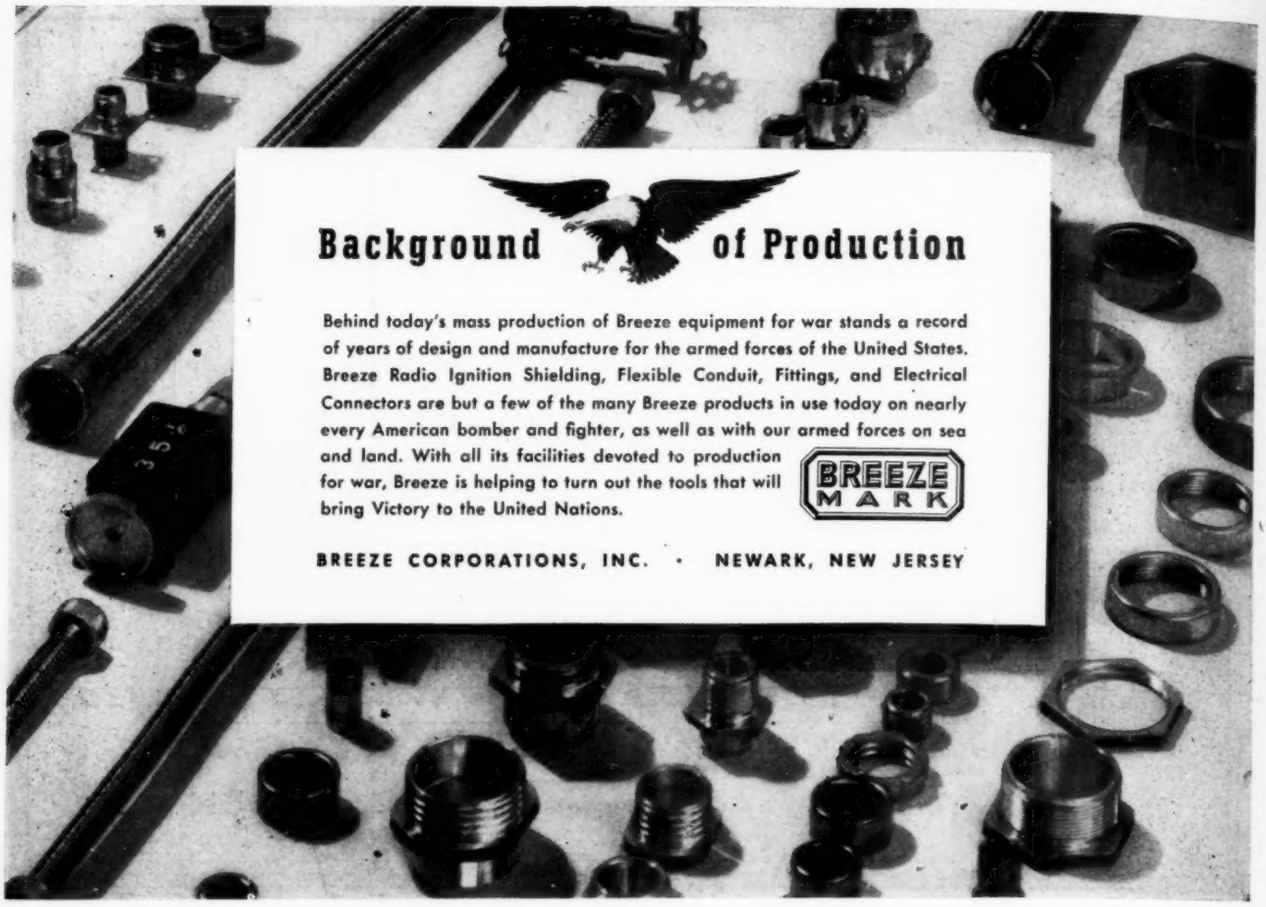
Background of Production
Behind today's mass production of Breeze equipment for war stands a record of years of design and manufacture for the armed forces of the United States. Breeze Radio Ignition Shielding, Flexible Conduit, Fittings, and Electrical Connectors are but a few of the many Breeze products in use today on nearly every American bomber and fighter, as well as with our armed forces on sea and land. With all its facilities devoted to production for war, Breeze is helping to turn out the tools that will bring Victory to the United Nations.
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37-mm. Antitank Gun

ARMY E NAVY

Awarded
November 4, 1942
1st Renewal
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Our Goal
10% By 100%

GUN CARRIAGES - RECOIL MECHANISMS - GUN BARRELS
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HIGH PRECISION WORK OF ANY CHARACTER

YORK SAFE AND LOCK COMPANY

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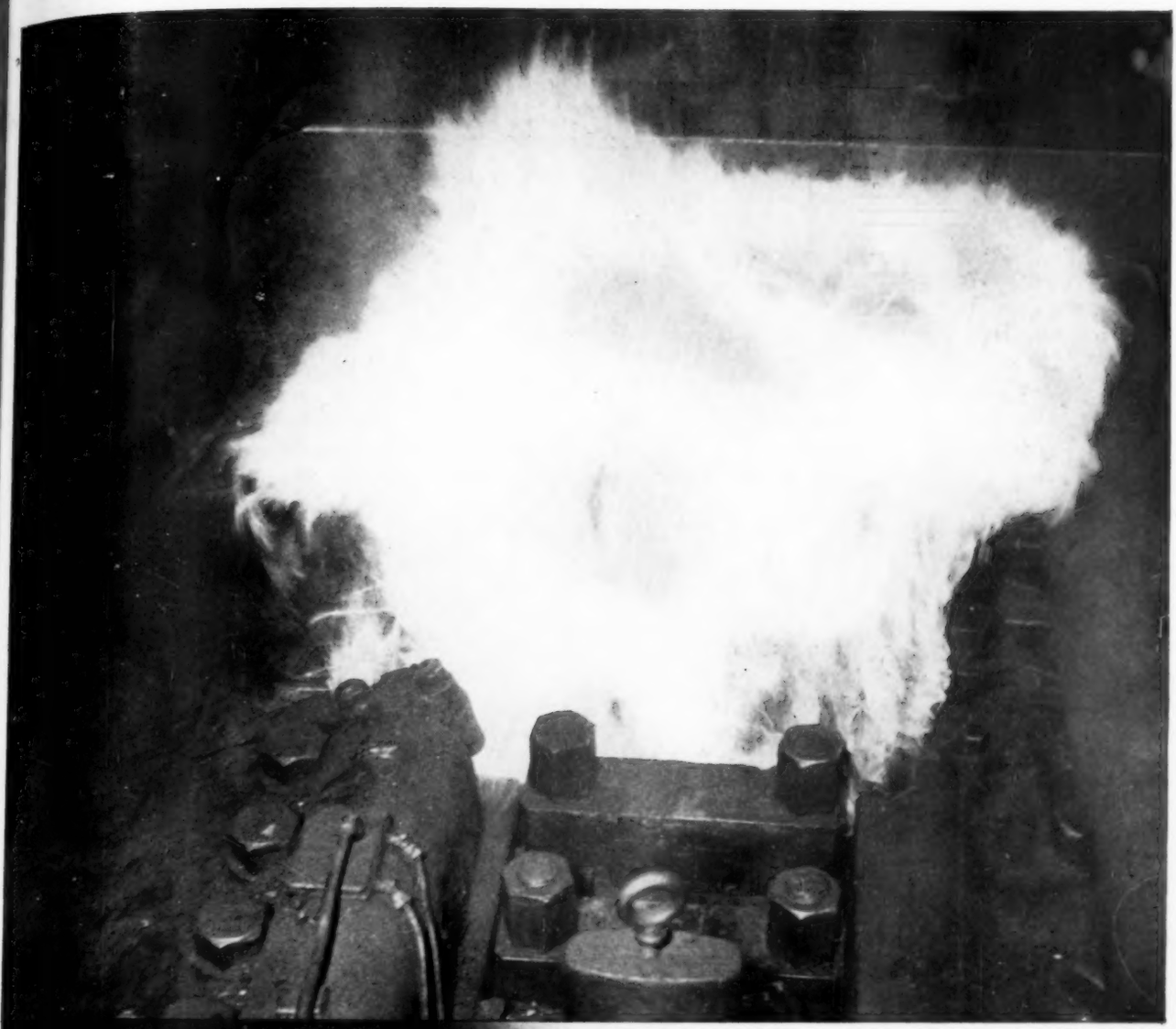

THAT SAVE HALF AN HOUR

Timken makes heavy gun tubes from Seamless Steel Tubing

...and materials had to DO *...and do it faster, better, than it had ever been done before.*

...ady of

...ously, we had promised to become the "arsenal of democracy" ...to arm our friends against our mortal enemies.

And we had to HURRY, HURRY.

But now the Japanese had poured their fury upon Pearl Harbor and it was no longer a matter of "cash and carry" or lend-lease or frontiers on the Rhine. American men and

American lives — AMERICA'S LIFE — *depended on it.*

The sheet of flame in the above picture is but one step in a secret process developed by The Timken Roller Bearing Company by which heavy gun tubes are made from Timken Seamless Steel Tubing — almost incredible savings of ... and steel. The breech ... 75 mm gun tube is be... in five seconds ... an op...

once required half an hour of vital time, made much scrap of scarce alloy steel.

The flame is one that leaps up many thousand times a month, one that will continue to leap up as often as the need may be, until the war is won. The Timken Roller Bearing Company, Canton, Ohio.

TIMKEN

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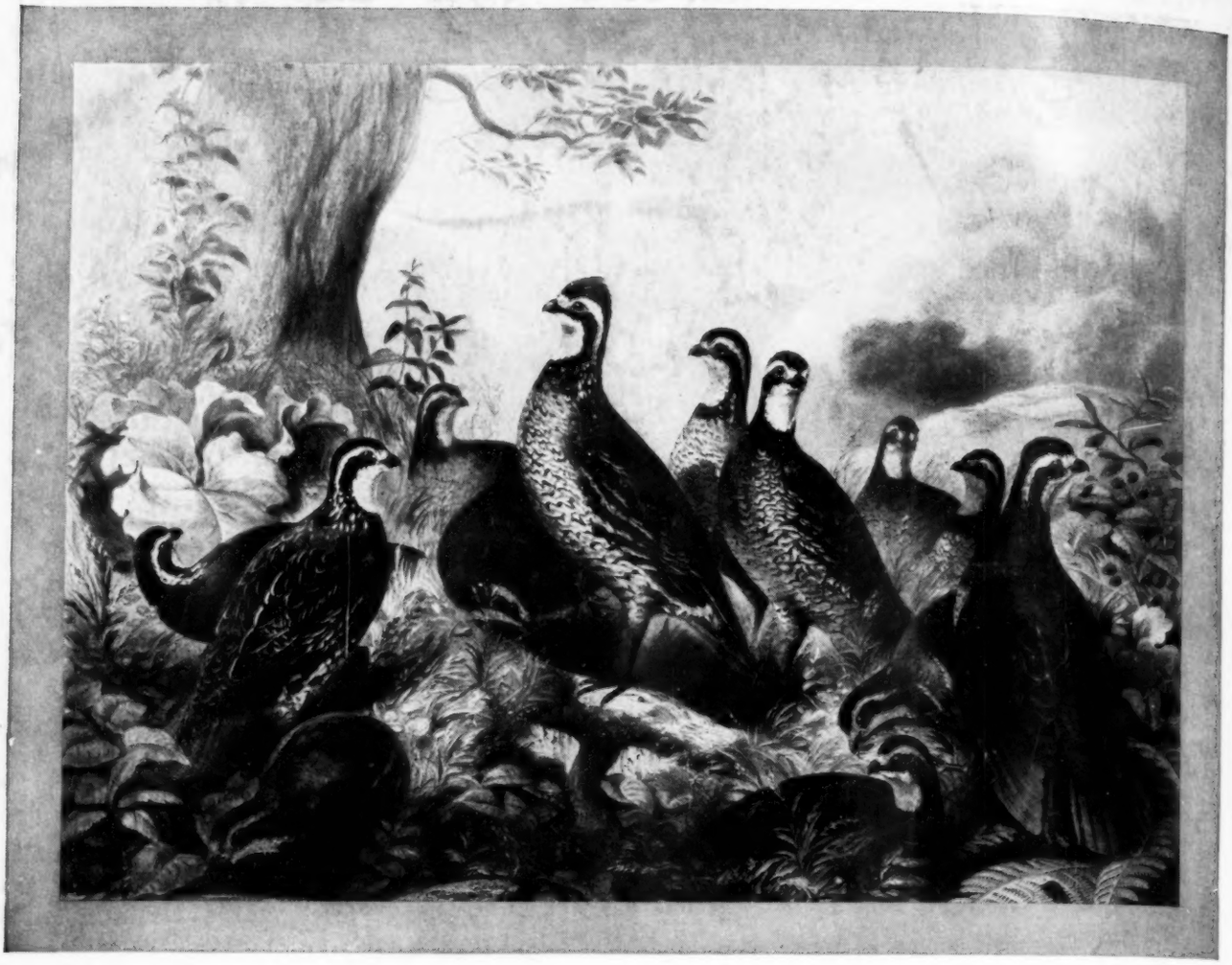
SEAMLESS STEEL TUBES



These families are sportsmen's responsibilities

If it were not for the splendid work of national, state, and local wildlife restoration agencies, certain species of game would almost surely be extinct today.

But wildlife restoration must be continued *steadily* if the American heritage of good hunting is to survive. Game is a *crop* — and must be tended as such — every year.

Since there are so many sportsmen now in the armed forces we urge sportsmen at home to do even more than their peacetime share in the restoration program. E. I. du Pont de Nemours & Co. (Inc.), Wilmington, Del.

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EXPLOSIVES & SPORTING POWDERS